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ABSTRACT

Described is a course on technology for undergraduate, non-technical students at the University of Utah. The course is designed to acquaint the students with the effects of technology and technological change on lifestyles and the issues which, when they arise, will require decision-making by intelligent citizenry. Materials necessary for participation in the course are summarized in detail in the report. (Author/SA)

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A GENERAL EDUCATION COURSE ON TECHNOLOGY FOR THE NON-TECHNOLOGICAL STUDENT

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COLLEGE OF ENGINEERING
UNIVERSITY OF UTAH 1970

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August 3, 1970

A GENERAL EDUCATION COURSE ON TECHNOLOGY FOR THE NON-TECHNOLOGICAL STUDENT

by

Noel de Nevers

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ABSTRACT

A course on technology for the non-technical student has been developed and tested at the University of Utah. The purpose of this course is to acquaint the non-technical student with the effects of technology and technological change upon his life and with the issues which he, as an intelligent citizen, will be called upon to decide.

The materials used for the course are summarized in this report in sufficient detail so that, using the report, faculty in other institutions may try out the course with a minimum of additional preparation.

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I. INTRODUCTION

A running complaint in the engineering colleges of the country for many years has been that the engineering colleges normally send their students to the Letters and Science part of the campus to take courses in humanities, social sciences, etc., in order to broaden their outlook upon life. On the other hand, the students from Letters and Science normally have no contact with the things taught in and by the professional schools on the campus. It is the opinion of most engineers that one can hardly consider himself an educated person if he has no understanding of how the engineering, legal, medical, etc., systems of the country operate and how these influence his life. As a step toward solving this problem, the College of Engineering of the University of Utah decided to offer a course for non-engineering and non-science students about technology and its impact upon their lives.

This course development program was funded by the National Science Foundation through Science Curriculum Improvement Grant No. GY-6386. The grant paid for the Project Director, Dr. Noel de Nevers, to spend the summer of 1969 preparing materials for the course, to work half-time during the academic year 1969-1970 in teaching the course and revising the materials, and to spend the summer of 1970 preparing this report.

The course has now been taught at the University of Utah for three consecutive quarters. The instructors were Noel de Nevers, Dr. Abraham Sosin, and Dr. Seymour B. Hammond. Dr. de Nevers prepared the basic material, Dr. Hammond and Dr. Sosin used the material without preparing major additional material and provided comments and questions on it. In addition, variants of the course have been taught as Honors Symposia by Dr. de Nevers in the Spring Quarters of 1969 and 1970.

The course, as currently taught, is open to all students from freshmen through seniors. The principal enrollment has been freshmen who are taking it as one of the electives in the general education program at the University of Utah. The typical class size is 50 to 70 students. The course is taught as a reading-and-discussion class. There is a relatively extensive reading list, consisting of books available in pocket book form and a set of readings which are reproduced for the course and distributed in a cover through the University Bookstore. For each reading, a set of discussion questions is handed out to the students. The class sessions consist of discussion led by the instructor on the material which has been read. Tests are all essay.

The purpose of this report is to summarize the available material for this course in sufficient detail so that faculty at other universities will be encouraged to use this material as the starting point for developing courses of their own. The course is an evolving one. The author makes no claim that this material is in final or perfect form; he only hopes that by distributing this material, he can encourage others to begin in the same general area and produce better materials of their own.

II. THE PLACE OF THIS COURSE IN THE UNIVERSITY

In 1969 the University of Utah revised its general education program so that all students who wish to receive a bachelor's degree from this university must complete at least three approved courses in any four of the five following areas: physical science, biological science, humanities, fine arts, social and behavioral science. The course outlined in this report is one of the approved courses for the social and behavioral science area.

In the formulation of the general education program, there was some discussion of a sixth area which would be called technology. It was hoped that enough courses could be developed from the professional schools to make such an area viable. We were unsuccessful at this; there simply were not enough suitable offerings. We are continuing our efforts to involve the other professional schools in the teaching of undergraduates.

There are other areas in which the professional schools can participate in the general education program. The University of Utah is beginning, in the fall of 1970, a sequence based on the "Man-Made World" material prepared by the National Academy of Engineering. Those familiar with that material will recognize that its focus is quite different from the material presented here, and the course has a different intent. That course sequence, when offered at the University of Utah in the general education program, will be one of the ways to satisfy the physical science area requirement.

There are numerous other analogous programs being tried at many universities in the United States. A listing of these and a newsletter for the exchange of information on them is being prepared by Professor Samuel T. Carpenter, Department of Engineering, Swarthmore College, Swarthmore, Pennsylvania, 19081.

III. PLAN OF THE COURSE

As currently taught, the course meets three days a week for a regular fifty-minute class session. In a ten-week quarter, there are normally thirty meetings. During this period, we attempt to cover the following six topics:

1. The complaints of the humanists that technology, really technological change, is causing evil effects.
2. How technological change comes about and a glimpse of the history of technology.
3. How we respond to technological change.
4. The various predictions of technological disaster.
5. The interrelations of various technologies.
6. Government science and technology policy.

In each of these areas, we have one major reading and several minor readings.

In addition to these six topics, two additional topics have been developed, but have only been tested on Honors students. These are:

7. The costs of technological safety.
8. Systems engineering-optimization-modeling.

The instructors vary in their requirements for papers and in their testing procedures. For an engineer teaching this course, perhaps the most difficult aspect is the paper and testing procedure. Those who have taught it have not found conducting discussions particularly difficult, but they find that their experience in giving exams in engineering courses is not particularly relevant to the problem of examining students on the material in this course. Examples of examinations and a list of paper topics are included; the author admits that these are the weakest parts of the preparatory material for this course.

In choosing paper topics, the goal has been to choose ones which will interest the students and require them to dig more deeply into some aspect of the subject being discussed. Some students have complained that some of the paper topics suggested were too technical, i.e., require too much scientific knowledge. I hope, by having the students write some of these papers, to convince them that they can learn to understand the contents of some technical journals or semi-technical journals. If I can convince non-technical people that they ought to be able to read and understand journals like "The Scientific American", I will have accomplished a significant part of my purpose.

In writing examination questions, I would like to find out which students have read the assigned readings and thought about them. Unfortunately, all of the questions I have devised give the advantage to those students who are articulate and can express their ideas well. I am opposed to tests which involve simple regurgitation of material presented by the instructor, but have not worked out a set of questions which really probe how well the student has thought about the material presented.

One of the problems we face in this course is the selection of paper readers and graders. For examinations in typical engineering subjects the answers are sufficiently accurately known that one can use graduate students in the discipline without difficulty. However, for this course the range of possible answers is

large, and we must place some part of the grade on the grammatical accuracy of the English and the quality of the communciation skills used. This makes it doubtful that the typical engineering graduate student would be a suitable grader. For this reason none of the three instructors who have used this material at the University of Utah have used graders. If the numbers of students wishing to take the course increases significantly, we will certainly have to find some way to provide graders for the course.

In the list of paper topics for this course there are none which are book reports. In the most recent Honors session of the course I accepted book reports as suitable paper topics. This seemed to be a fairly successful procedure. I plan to use it in the near future in the technology course as offered for the general student. There now exists numerous bibliographies of books, papers, etc., which bear on this general topic. These can be used to select reading lists for the course. Examples of these bibliographies are, "Science for Society-A Bibliography," prepared by the American Association for the Advancement of Science and the Battelle Memorial Institute. Copies may be obtained from the Battelle Memorial Institute, Columbus, Ohio. Another bibliography is Lynton K. Caldwell and William B. Deville, "Science, Technology, and Public Policy," several volumes, Department of Government, Indiana University, Bloomington, Indiana, 47401. I am certain that other such bibliographies exist and will provide suitable reading lists for assigning book reports as paper topics.

One criticism which I have received from some reviewers of this material is that it does not sufficiently emphasize the positive aspects of technological change. Our modern, technologically-based society has brought more material wealth, comfort, health and leisure to our people than were ever known in any previous society. I have not emphasized this because the students know it. This does come up some in the discussions, but the students seem to take it for granted. Perhaps they are not aware enough of how poor, overworked and unhealthy their ancestors were. For this reason, some such comments by the instructor might help.

Another topic which I have not introduced very strongly, but which I feel could be introduced quite profitably, is the consequences of the current biological revolution. It seems clear that within our lifetime we will be able to use genetic manipulation, artificial stimulation of intelligence, large scale organ transplants, chemical control of behavior, and other very far-reaching biological changes in the human race. There are some very severe ethical and moral questions as to which, if any, of these things we should do and under what circumstances. I have not introduced this material into the course for two reasons: First, I do not feel personally competent to discuss at a technical level what the likelihoods of these accomplishments are. Second, I have tried in the past and am continuing to try to interest the University of Utah College of Medicine to undertake a course similar to this one which would deal with questions like the ones above and like the questions of how our health industry should be run. I think it would be best if we could interest someone with a medical or biological background to tackle this set of problems rather than having engineers undertake it.

In teaching this set of topics, the other instructors and I have felt that our personal background in the areas was probably inadequate to do a really thorough job. Faced with this inadequacy, we could choose to not try at all or to line up a group of experts who would each take some part of the course, or to admit our limitations and go ahead. We have chosen the latter course. It is

my belief that one will never find the perfectly-prepared expert to talk upon the implications of technology; therefore, one ought to settle for one with reasonable preparation and with a rather wide background of reading in the subject. Although our preparation is certainly inadequate, it is superior to that of the students, and they seem quite willing to accept our limitations and our willingness to tell them that we do not know the answers to some specific questions. We recommend that other faculty members, in preparing to use this material similarly accept their limitations and proceed with candor.

Inevitably in preparing such material and evaluating it, one must form personal judgments as to which item is most suitable for use in a given place, etc. One must also form personal judgments about the accuracy and wisdom of various statements made by the authors whose works are being used. In the following material I have made no effort to hide my personal beliefs and prejudices. I could convey the same information by using the circumlocutions of, "it is the opinion of the author that," or, "in the considered judgment of a body of experts it appears that, etc."; but these certainly deceive no one.

IV. INDIVIDUAL TOPICS

The eight topic areas which have been developed and are ready for use in the course are presented in this section. Each topic is presented in the following order: introduction, list of reading materials with comments thereon, questions for the reading materials and my answers to those questions, additional materials, examination questions on this subject, and paper topics on this subject.

All of the readings discussed here can be obtained in any University Library. Therefore, the readings themselves are not duplicated here, but only the discussion questions and my answers to the questions. However, as a convenience to readers who may wish to have an assembled booklet of these readings, such a booklet is available from the University of Utah for $5.00. Instructions for obtaining these are on page 109.

The questions reproduced here are exactly as they are distributed to the students. Before each set of questions I have included a very brief description of the article or book in question. This is intended as a convenience to the reader of this report. Such descriptions are not distributed in class, nor are my answers to the questions.

IV-A. Topic 1. The Complaints of the Humanists

There is a large body of vociferous public opinion which takes the view that modern technological change is leading to very evil consequences. This opinion should be considered by anyone who considers himself to be an informed human being.

Behind this current attack on our "Technological Society" is a second theme which is not as clearly expressed, but which I think is as significant. This is the theme that industrialization and mechanization of life is basically evil and diverts man from his "natural" state. This theme goes back at least as far as Rousseau and possibly even further.

A third theme which seems to be interwoven with these complaints is the theme which goes back at least as far as Aristotle. It is that the mechanics of providing the material needs of mankind are basically sordid and that those who provide these needs are inferior people.

These three themes are to some extent interwoven in the material presented in this section. At times it is difficult to sort them one from another. However, these have been a significant increase in volume of this kind of criticism in recent years. The criticisms of Aristotle and Rousseau have been with us for a long time and attracted relatively little attention. However, in modern times many more observers of our society have become aware of the effects of technology and technological change and have raised their voices in the kinds of criticisms discussed here. The objective of this section is not to answer these criticisms completely or to make a full analysis of possible answers, but rather to introduce the student to this body of criticism and use it as a way of introducing the other materials in the course. By the end of the course the student should make up his own mind as to the validity of the criticisms presented in this section.

Taking these themes in reverse order, we begin with several quotations from Aristotle which appear in his "Politics" (Loeb Classical Library, London 1932).

> "....it is therefore clear from these considerations that in the most nobly constituted state, and the one that possesses men that are absolutely just, not merely just relatively to the principle that is the basis of the constitution, the citizens must not live a mechanic or a mercantile life (for such a life is ignoble and inimical to virtue), nor yet must those who are to be citizens in the best state be tillers of the soil (for leisure is needed both for the development of virtue and for active participation in politics)." (page 575)

> "And it is also manifest that the properties must belong to these classes, inasmuch as it is necessary for the tillers of the soil to be slaves, or serfs of alien race." (page 577)

> "It is therefore not difficult to see that the young must be taught those useful arts that are indispensably necessary; but it is clear that they should not be taught all the useful arts, those pursuits that are liberal being kept distinct from those that are illiberal, and that they must participate in such among the useful

arts as will not render the person who participates in them vulgar. A task and also an art or a science must be deemed vulgar if it renders the body or soul or mind of free men useless for the employments and actions of virtue. Hence we entitle vulgar all such arts as deteriorate the condition of the body, and also the industries that earn wages; for they make the mind preoccupied and degraded. And even with the liberal sciences, although it is not illiberal to take part in some of them up to a point, to devote oneself to them too assiduously and carefully is liable to have the injurious results specified." (page 638-9)

Needless to say, these ideas are repulsive to most engineers. This viewpoint of what is right and proper was entirely feasible for a man who lived in a society where all manual labor was conducted by slaves. One can have a very lofty and refined view of what is right and proper for human beings as long as someone else does all the work. These quotations are cited only to show that in many of the readings which follow the suggestion is really made that those who do not "dirty their hands" with the real running of our society are the only ones who are qualified to speak upon what is good and right. As an engineer, I take a very hostile view of this idea.

To introduce the second theme, I quote from Rousseau"s "Discourse on Inequality."

"As long as men remained satisfied with their rustic cabins; as long as they confined themselves to the use of clothes made of the skins of other animals, and the use of thorns and fish-bones, in putting these skins together; as long as they continued to consider feathers and shells as sufficient ornaments, and to paint their bodies of different colors, to improve or ornament their bows and arrows, to form and scoop out with sharp-edged stones some little fishing boats, or clumsy instruments of music; in a word, as long as they undertook such works only as a single person could finish, and stuck to such arts as did not require the joint endeavors of several hands, they lived free, healthy, honest and happy as much as their nature would admit, and continued to enjoy with each other all the pleasures of an independent intercourse; but from the moment one man began to stand in need of another's assistance; from the moment it appeared an advantage for one man to possess the quantity of provisions requisite for two, all equality vanished; property started up; labor became necessary; and boundless forests became smiling fields, which it was found necessary to water with human sweat, and in which slavery and misery were soon seen to sprout out and grow with the fruits of the earth.

Metallurgy and agriculture were the two arts whose invention produced this great revolution. With the poet, it is gold and silver, but with the philosopher it is iron and corn which have civilized men, and ruined mankind...."

Basically this is the argument that only in the "state of nature," in which man supplied his wants by direct hunting, gathering, etc., was man happy. As far as I know, no modern scholars take Rousseau very seriously. Certainly the observation of current primitive tribes does not indicate that their life is as idyllic as he believed. However, this theme also persists through the other

writings discussed in this section. The harkening toward the golden age when men didn't dirty their hands with mechanical contrivances is a strong one.

The main theme that modern technology and technological change are destructive is taken up in many current books, e.g., Jaques Ellul, "The Technological Society." However, for the purposes of this course, I consider the best book on this topic to be Aldous Huxley's, "Brave New World." It is selected because it is (1) available in an inexpensive paperback, (2) light, entertaining reading, (3) quite prophetic in many ways (written in the early 1930's), and (4) the most illustrative of the themes which come up in this topic.

The other readings for this section are Nigel Calder's, "Tomorrow's Politics, the Control and Use of Technology," Wilbur H. Ferry, "Must We Rewrite the Constitution to Control Technology?", and Hyman Rickover, "A Humanistic Technology."

As a final reading and discussion, we use James K. Fiebleman's, "Pure Science, Applied Science, Technology, Engineering: An Attempt at Definitions." This set of definitions are good for starting a discussion.

IV-A-1. Discussion questions and answers for Topic 1

Discussion questions for Aldous Huxley, "Brave New World" (Bantam Paperback Edition, 1958).

"Brave New World" is a science-fiction story set 700 years in the future. In it a world government has taken over the complete direction of all aspects of the lives of the people. In this world pain, suffering, want and hardship have been completely eliminated, but at considerable cost in individuality. The story is set in England; an outsider, who by accident was raised on an Indian reservation and learned about England through the collected works of Shakespeare, comes into the society. His conflict with the "Brave New World" is the vehicle Huxley uses for showing the problems of a world in which we have sacrificed individuality for material comfort.

1. What, in 50 words or less, is the basic message of this book?

2. Does Huxley have a positive, negative, or neutral attitude toward the "Brave New World" he pictures?

3. One of the major areas of conflict between Savage and Lenina is over their different concepts of self-denial and the need for suffering. Huxley is suggesting that technological advance will make possible instant gratification of all physical desires, and make labor and pain unnecessary. Assuming he is right, would you vote for such a situation? Or do you agree with Savage that this would degrade you?

4. In the book is the position of the individual, as an individual, stronger or weaker than in our present society?

5. In which general areas were his predictions of technological change most speculative, i.e., farthest from current fulfillment? In which areas were they most conservative, i.e., of things which we have long since fulfilled? Is there an obvious reason for this difference?

6. In chapter 12 (p. 119) is a passage beginning, "A new theory of Biology..." Some students say this is a parallel to the "grand inquisitor" section of "The Brothers Karamazov," by Dostoyevski. Is it a good parallel? Is Huxley right in the parallel?

7. In chapter 3 (p. 67) Lenina says, "....Progress is lovely...." Is this a commonly held belief in the BNW? Is it consistent with the other beliefs and policies of the rulers of BNW?

8. Why did Huxley pick Ford as the new god? Whom would he pick if he were writing today?

9. Why is there the strong emphasis on consumption of material goods in the book, e.g., the comments on page 33?

10. On the botton of page 125 Helmholz shows his complete inability to comprehend the Romeo and Juliet story. Why cannot he comprehend it?

My answers for "Brave New World".

1. If left to themselves, the technologists would produce a world, which is comfortable, convenient, secure and healthy and utterly destructive of the human spirit.

2. To my amazement a few students thought that the author had a positive view of this world. As I read the book, he has a highly negative one.

3. I can do without involuntary labor, hunger and involuntary hardship. Whether I can do without self-denial is an interesting question, which philosophers have wrestled with for a long time.

4. I would say much weaker.

5. His biological predictions are yet to be fulfilled, for example: bottle-birth, soma, youth to age 60 followed by short and painless deaths, etc. On the other hand, his mechanical and electrical predictions were all long since covered. For example: the loud speaker speaking to the Epsilon, telling him what to do was long since outmoded by automatic controls. The radio operator on page 169, who goes through an amazing rigamarole in order to transmit his message, has long since been rendered outmoded by far superior radio devices. The helicoptors he predicted as a wild, far-out impractical device are now available.

   I think the reason is that his background is in a famous biological family. One normally tends to look for advances in areas he knows something about and to be much more conservative about advances in other areas.

6. I think its an excellent parallel. In the dream in "The Brothers Karamazov," the priests are the ones who accepted the responsibility of caring for the ignorant masses. Huxley is suggesting that in the "Brave New World," the technologists would be obliged to make the same decisions.

   Most freshmen of the University of Utah have never heard of "The Brothers Karamazov." Upper class Honors students are all familiar with it.

7. They believe it because they are taught it. It is obviously not consistent with the other things because progress means change, and what they want is "identity, conformity, stability." This is direct contradiction, which can only be accomplished by "double think."

8. Ford was the archetype of the Machine Age in 1933. Note, in the last paragraph on page 25, that he uses Ford and Freud interchangebly. In several class discussions people suggested that rather any one person, they would pick IBM as a symbol of our age. Some others said that Ford is still the best.

9. This book was written at the start of the great depression when it seemed clear to everybody that what was needed was much more vigorous consumption.

10. Helmholz has been completely brainwashed. In the seven centuries since the takeover by the technologists, they have done a good job of suppressing history. One wonders whether we have equally forgotten history and are unable to understand what went on in the past. I think not. Shakespeare is still quite clear to us and Aristophenes is reasonably clear. On the other hand, the Russians seem to have been able to brainwash even their brightest people to believe their versions of history.

Discussion questions for Nigel Calder, "Tomorrow's Politics: The Control and Use of Technology," The Nation, 200 (Jan. 4, 1965), 3-5.

This article suggests that we need to include control and direction of technology as a major political issue to be debated in all political campaigns. The author claims that by merely continuing our present course of no political intervention in technological decision making, we will end up with a very poor society.

1. Suppose someone did offer you the future cited in the first paragraph of this article. Would you vote for it? Suppose your choice is that future or maintenance of society exactly as we know it now. Which of these would you choose? Assuming you can write the prescription for the kind of world we want in the future and you don't like the one proposed here, what would you propose?

2. In the western world we are proceeding pretty much on the basis that any new technology can be introduced if some person or group is prepared to do so. In the USSR and the communist countries of eastern Europe new technologies are not introduced without government sanction. What technological innovations which are present in the west have they kept out of their countries? Assuming that you are now Premier of the USSR and able to decide which technologies should be excluded, which would you exclude?

3. He suggests that there should be someone to oppose new technologies so that their drawbacks can be examined before they are approved. You have been appointed to do so for the following products: (a) the in-sink garbage disposal unit, (b) the snowmobile, (c) the pocket transistor radio. What drawbacks would you list for each?

4. What technological advances in recent years have had the effect of causing a net decrease in personal freedom, if any?

My answers for Nigel Calder, "Tomorrow's Politics, etc."

1. Probably not, because the present society is unstable. It is most likely that war, population, exploitation of consumable resources, etc., would lead to truly awful consequences and, therefore, continuing on the course he proposes is a suicidal course. The choice between that and the status-quo is a choice between Scylla and Charybdis. Most students saw that what one has to do is to choose the good parts of the advance without being stuck with the bad parts.

2. I know of no examples. If I had 100 percent control, I certainly would not bother with most cosmetics, cigarettes, most harmful drugs, probably not with private autos, color television, stereos. The Soviet leaders are limited by the fact that they have contact with the west and must provide for their people those things which their people know exist in the west. This raises the interesting question as to whether the Chinese leaders, who have probably done a better job of insulating their society from contact with the west, are better off in this regard. I don't know and none of the students knew either.

3. a. The garbage disposal resulted in severe overloads on sewage treatment plants and stream pollution and also in significant waste of food. Before we had the garbage disposal, surplus food ended up being fed to hogs. Some communities went so far as to ban the garbage disposal because of the problem of the sewage plant overloads, but the outraged consumers made them either dump the waste into the streams untreated, or build new sewage treatment plants.

   b. The snowmobile certainly makes mountain cabins subject to winter vandalism, which they never were before. One can tell here the interesting tale of the oxyacetylene torch, which I understand was originally banned in many countries because it made it possible to open all existing safes very simply. Ultimately, the uses that were good enough outweighed this hazard and people used them. The owners of safes were obliged to buy new safes. I do not know the source of this story, nor whether it is true. I would be grateful if someone would tell me. It appears that people who own mountain cabins will now be obliged to clean them out completely in the fall, or pay higher insurance rates. Another difficulty with the snowmobile is the upsetting of wildlife by people in snowmobiles going into areas which normally have been quiet for wildlife in the winter. Certainly the esthetics of being out in the country in the snow have been greatly harmed by the noise and smoke that these things make.

   c. This makes it possible for kids to listen to radios in school, thereby not paying attention. My kids do this. It also has made possible the distribution of propaganda in non-literate societies. It is most likely that Gamal Abdel Nasser would not have been as effective a leader if he could not count upon cheap transistor radios to carry his word into all the villages in the backward countries he is powerful in. Also, this makes the invasion of privacy in public places much simpler because one is obliged to listen to these, whether he likes it or not.

4. Most often a technological advance increases one group's freedom or ease at the expense of another group. For example, the automatic elevator increased the speed and efficiency and lowered the cost of living or working in tall buildings. It wiped out the jobs of those who had previously been elevator operators. The snowmobile increases the pleasure in the out-of-doors of those who like to travel in noisy ways, it greatly decreases the pleasure in the out-of-doors to those who like quiet. Some students cited the computer as a net-decreaser of personal freedom, but when the discussion gets going it becomes clear that if we were to do away with it and go back to doing all those things by hand, our freedom would be greatly reduced. One suggestion which was made was that electronic eavesdropping devices decrease freedom; I am afraid I have to agree with that one.

Discussion questions for Wilbur H. Ferry, "Must We Rewrite the Constitution to Control Technology," Saturday Review, 51 (March 2, 1968), 50-54.

He suggests that a complete overhaul of our Constitution is needed to control what he considers as malignant technology. He cites several examples of what he considers malignant technology.

1. In the middle of the first page he says that scientists have been more conscientious than the technologists in warning society about the consequences of their actions. Cite examples to support this remark.

2. In the middle of the first page he speaks of "the castration of the spirit by technique." Cite examples of technological activities which "castrate the spirit."

3. In the middle of the second page Ferry decries the invasion of privacy which modern technological advance is making possible. Do the citizens of modern industrial societies, like the USA, have more or less privacy than citizens of non-industrial countries like those of the Middle East, Africa or South America?

4. In the middle of page 52 he says, concerning smog, that "Technology is the villain." Is that right? Would you be willing to give up all autos in order to eliminate smog, if that would do it? Do you think that society would do so by a free election?

5. On page 53 he says, "....impersonality and standardization are the very hallmarks of technology." Is that right? Does each technological advance result in loss of personality and individuality?

6. Do you agree with his statement of page 54 that "...technology is indeed the main conundrum of American Life"? If not, what is?

My answers for "Must We Rewrite the Constitution, etc."

1. He must be talking about the famous Atom Bomb letter, which a group at Los Alamos wrote in 1945 asking that the first bomb not be dropped on people.

2. No one had a good example for this one. One wonders about the following questions: Did photography kill painting or did it liberate it? Did the movies kill theatre or did they liberate it? Does the division of labor destroy the joy of craftsmenship? Did television wipe out reading? Did

television wipe out political debate, giving us canned candidates or has it ended up with us having a better view of what our candidates are like? Has bulk processing lead to utterly tasteless food? (My answer is yes). Has our ease of movement caused us no longer to see the land as we pass through it? Have household appliances liberated women, or taken away their role in life?

3. I say more. Probably not ten percent of the kids in the classroom have witnessed their parents having sexual intercourse. In the one-room huts, all the kids have. Many pre-industrial cultures do not consider privacy a positive good because it is something which is simply not possible for them.

4. No, I think he is completely wrong. People are the villians because their sense of values are different than his (and mine). Yes, I would give up the automobile if we had good public transport and ancillary services, but I do not believe the populace would.

   One could equally well consider the crusades or the inquisition and say "religion is the villain." In that case one would be equally wrong. The problem is that people have misapplied something--in one case, the teachings of Jesus Christ, in another case modern technology.

5. It can, but it need not. Mostly it offers meaningless choices. To those who wish a variety of life styles, modern technological society offers a great deal more choice than any previous society.

6. No. I would put the problem of Nuclear War, which is really foreign policy and human relations problem first and the problem of racism and its consequences second. Technology comes in a poor third, if at all.

Discussion questions for H. G. Rickover, "A Humanistic Technology," Nature, 208 (Nov. 20, 1965), 721-6.

He shows examples of what he considers the misuse of technology and prescribes a much better controlled technology as the cure of these abuses.

1. In his third paragraph he says that technology may enable human beings to become more truly human. What is his definition of truly human? Do you agree with it?

2. The quotation from Vannevar Bush at the end of page 721 was presumably made in the 1940's. Has anything happened since then to change our view on this subject? Would modern scientists endorse Bush's statement?

3. On the second page he states his belief that technological changes should not lead to changes in morals or ethics. Do you agree? If not, cite examples of acts which were once moral or ethical, and now, due to technological change, are not; or acts which once were immoral and unethical, and now, due to technological change, are not.

4. On page 722 he says, "a certain ruthlessness has been encouraged by the mistaken belief that to disregard human considerations is as necessary in technology as it is in science." Is it necessary in science? Show some examples of the encouragement of ruthlessness in technology for this reason.

5. On page 723 he claims that those who use technology unwisely defend themselves against attack by citing the Galileo analogy. Show an example of this.

6. In the example he cites on page 723-4 of the destruction of whales, is the problem of technology destroying whales or of technology placing power to destroy them in the hands of men who are foolish and greedy enough to do it?

7. On the right hand side of page 724 he lists the defenses which are normally made by those who apply a technology which is under legislative attack. Cite recent examples in which these steps have been followed, pretty much in the order he lists.

8. Do you agree with his attack on social sciences at the lower right on page 724? If not, why do you think it is wrong? Why does he make it?

9. On page 725, middle right hand, it seems to me that he is saying that society should stop trying to tell the engineers what to do. Yet earlier he seems to say that society should take over the direction of technological advance. Is this what he says? Is this a contradiction? If so, how should it be resolved?

My answers for "A Humanistic Technology."

1. He means free from deadening physical labor and free from having to strive to provide food and clothing and shelter. I am inclined to doubt that definition. After all, these are things that only human beings do; animals don't plow fields or mine coal or do clerk work, so maybe deadening physical labor is what is truly human. If, on the other hand, one argues being truly human means being able to develop one's intellectual, spiritual, artistic faculties and the like, then it is certainly true that technology increases the possibilities for doing this. By "truly human" he must mean only the highest quality activities which are peculiar to humans.

2. My answer would be yes to the first question and no to the second. Surprisingly, the students' answer generally is no. One of them said that these things are permanently unknowable empirically. This raises the question of how one decides what are the members of the class "empirically unknowable." My answer is that that class is identical with the class of things which are unreal and I do not think the things he is discussing are unreal.

3. I disagree with him, if he means that it should not cause changes in the details of our moral and ethical codes. If by moral and ethical code he means do good, avoid evil, minimize harm to others, then I see no reason that technological change can ever change that. If, on the other hand, he means specific provisions as to what is or is not right, then I think he is completely mistaken. As examples: Consider the question of all-out war. At one time this must have been a morally acceptable thing; certainly the American Revolution was an appropriate all-out war. I do not believe this is morally acceptable now. There are numerous ecological examples; when people settled the West there was no reason at all not to put your excreta in the local stream. It didn't make any difference to them; it does now. Before cesarian sections were developed, if one had sexual intercourse with

a very narrow-hipped wife, one was killing her just as surely as if he put a gun to her head and pulled the trigger. However, a gun would be quicker and less painful. By any reasonable standards that was an immoral act then; it isn't now. The classic example is the change of attitude of the Roman Catholic Church on usury in the Middle Ages. This was immoral until they saw that venture capitalism had a great deal of benefits, at which point it ceased to be immoral.

4. I know of no examples to justify that statement at all, nor did any student.

5. Here, also, I know of no examples, nor did any student.

6. I think clearly this is a case of technology placing power in the hands of those who are ignorant and greedy.

7. The response of the auto companies to Ralph Nader's safety campaigns follow this procedure exactly. Similarly, the response of the cigarette manufacturers to the evidence about health and cigarettes follows this line exactly.

8. That is obviously nonsense and reflects the fact that he was raised in an era in which engineers were taught to have contempt for social sciences. I hope we are past that sad point.

9. I feel he is completely contradicting himself here. What he really should be saying is that frequently businessmen over-rule engineers and apply narrow standards. The real enemy are those who over-rule the judgment of the technically competent, to do technically incompetent things. I certainly wish that engineers had a better record of standing up for what they knew was right.

Discussion questions for James K. Fiebleman, "Pure Science, Applied Science, Technology, Engineering: An Attempt at Definitions," Technology & Culture, 2 (1961), 305-317.

He presents a set of definitions concerning pure science, applied science, technology, engineering, etc. These clearly reflect his background as a philosopher.

1. Is his statement on the second page that, "without pure science there would be nothing to apply," correct? Cite examples of important scientific discoveries which came about as a result of the investigation of some practical problem, and of important discoveries which came about as a result of investigations with no practical end in mind.

2. The question is often debated as to why society does or should support "pure science." The pure scientists suggest that pure science should be supported because it is one of the greatest, (if not the greatest) human intellectual undertaking, and has a beauty and glory of its own. ("Science for science sake," just like "Art for Art's sake.") Some detractors say that really society supports pure science because of the practical results which flow from it, and that if there were none of those, society ought to tell the scientists the same thing it tells the painter; namely, either produce what will sell, or support yourself some other way (e.g., teaching) and consider painting your hobby. Which, if either, of these views is correct?

3. On page 308 he refers to "Pasteur's Principle of Pure Science that dead...." Did Pasteur find this principle by the methods of "pure science?"

4. On page 309 in the first paragraph he expresses his preference for pure over applied science. Do you agree? If so, why? If not, why not?

5. Which, if any, biases do you think the author brings to his topic?

6. Based on his definitions, or on whatever definitions you think proper classify the following as pure scientist, applied scientist, technologist, or none-of-these categories: Enrico Fermi (theoretical physicist and principal scientific and technical director of the World War II atom bomb project); typical U.S. physician; typical U.S. highway engineer; typical U.S. lawyer; typical U.S. automobile mechanic; typical U.S. commercial airline pilot; typical U.S. school teacher; Werner von Braun; Jonas Salk; Pasteur; Christian Barnard; Henry Ford?

7. This paper contains some very inaccurate historical statements. Cite some of these.

My answers to the questions for Fiebleman, "Pure Science, etc."

1. No, I do not think it is correct. Early astronomy was all based on the practical problem of getting a good calendar. The scientific results were a fallout from the practical ones. Thermodynamics largely came out of the steam engine. Most theoretical chemistry, at least in the early days, came out of practical applications. Quantum theory came out of Plank's investigations of radiative heat transfer. Most of our physiological principles came about from practical attempts to figure out ways to keep people healthy. On the other hand, most recent work, particularly in Physics, has not had immediate practical goals but is directed at trying to understand the microscopic details of matter. Perhaps we have seen a reversal from the practical leading theoretical with the Manhattan Project as the first major example of the theoretical leading to the practical.

2. Perhaps society should support both artists and scientists the same way. However, considering the differences between the two, it is very clear that the scientists can show practical advantages to their work, at least over the long run. Also the scientists have agreed upon methods of judging the quality of work so that one has a way of knowing who is making a contribution and who isn't. It is a great deal more difficult for artists to agree upon such a thing. Is Andy Warhol really contributing?

3. Pasteur was working on the practical problem of the spoilage of wines, when he discovered his principle. To call this a "principle of pure science" is absurd.

4. I certainly don't agree, because I am an engineer.

5. Clearly he reflects the biases that go with his background as a philosopher. Philosophers are obviously much more attracted to pure science than they are to its practical application.

6. I propose the following definitions:

   a. A pure scientist is one who works on a scientific question for which he can imagine no practical application.
   b. An applied scientist is one who does scientific research directed at the solution of specific practical problems.
   c. A technologist is a person who uses currently known scientific principles and data in order to solve practical problems.

   Using these, I would say that Fermi, during various points of his life, was a pure scientist, an applied scientist and also an outstanding engineer. The typical U.S. physician whould be a technologist (physicians use this word to describe what we would call a lab technician, therefore, are very angry when anyone suggests that they are technologists. It is simply a case of the word having different meanings in different areas. According to the definitions that we use, physicians would definitely be technologists). A typical highway engineer would be a technologist. He also turns out to be a manager of operations. For a lawyer, it is a very mixed question as to whether or not a law is a technology. If by "technology" you mean "the learned application of a body of principles and rules," then certainly law is a technology. If you insert in your definition the words "scientific principles and rules" or "physical-scientific principles and rules," then law is not. This leads to an interesting discussion. An auto-mechanic would be a technologist or a technician. If one wishes to make the distinction between the two, one would say that the technologist is applying science and the technician is following rules set down by the technologist. This is an arguable definition, but I like it. The airline pilot is a technologist or a technician, or perhaps ar artist, since the things he does frequently cannot be described in detail. One must feel them and try them. A school teacher is a technologist to the extent that we know how to teach and a technician to the extent that she simply follows a set of rules set down by others. Werner Von Braun is a technologist. Jonas Salk is certainly a technologist, possibly an applied scientist. Christian Barnard is a technologist and Henry Ford, a technologist and businessman.

7. The line on page 313 about gasoline not being the product of the technologist is complete nonsense and bad history. The one on page 315 about pure scientists working without thought of personal gain is manifestly absurd. Anyone who doubts that should read James Watson's, "The Double Helix," (which is recommended reading anyhow, whether you read it for this purpose or not).

IV-A-2. Additional materials for Topic 1

The following discussion and materials were prepared and have been used, but are not now currently part of the basic package for Topic 1. The first of these is Russell Baker's, "Give Me Your Tired, etc." This is one of Russell Baker's typically humorous sallies into American politics which I enjoy very much, but which the students did not seem particularly impressed with. It has been excluded from the list of topic readings for this section because we had too many. The next is Jerome B. Weisner's "Science and Technology," etc., which was used and is satisfactory, but does not seem to be as well liked by the students as the other ones in this section and was excluded because we had too many. Finally, there is the reading from Jean Jacques Rousseau. This was

used in an Honors section of the course and received a fair reception there. Whether it would be suitable for a general section is questionable.

There are numerous other materials which one might use in this section. One student wrote an interesting paper suggesting that "In the Penal Colony," by Franz Kafka, was a suitable reading. This is an interesting short story which can be construed to be a parable about technology and the role of the technologist, etc. I do not find the symbolism so clear that this is certain. This was tried as a reading in an Honors section; the response was fairly negative.

An additional body of literature which one might consider here is that written in the period 1850-1920 attacking the abuses of the industrial revolution. Examples are the writings of Charles Dickens (e.g., "Oliver Twist"), or of Emil Zola (e.g., "Germinal"), or Upton Sinclair ("The Jungle"), etc. In these writings the complaints are made that the new factory system has led to truly intolerable conditions for the workers. I consider this a separate topic from the topic considered here. It is not particularly timely in the United States. Most of the conditions which were complained about in these writings (child labor, extremely long working hours, lack of workmen's compensation, extremely hazardous working conditions, etc.) have largely been eliminated in the United States. (This is the case for most factory workers, but not necessarily for agricultural workers and migrant laborers.) Therefore, I have not included this set of complaints in the course.

Discussion questions for Russell Baker, "Give Me Your Tired....Poor - If They Can Build Super Jet," New York Times Service, appeared in S.L.C. Tribune, October 10, 1967.

This is a humorous attack upon the Congress of the United States for providing federal funds to support the SST project.

1. Is he correct that we do technological stunts because that is what we are good at? If you think that is right, cite some other "technological stunts" we have recently done.

2. He is pretty hostile toward the SST. There must be some arguments to indicate that it is a good thing. What are they?

3. What is the equity and morality of sonic booms? Does the man with the airplane have the right to subject those on the ground to as much noise as he chooses? Does the man on the ground have any legal or moral right not to be disturbed? How are such questions settled in our society now? How should they be settled?

4. In the case of sonic booms we seem to have decided that the man with the machine has automatic rights to do what he could not do without the machine, or automatic rights over other people. Can you cite other examples where the man with the machine is allowed to do what a man without a machine would not think of doing?

My answers to "Give Me Your Tired, etc."

1. The class was bright enough to quickly discover that one ought to have a definition of a technological stunt. We thrashed with this for some time. My conclusion, which the class sort of accepted was, "a technological stunt is some undertaking, in which the real purpose is the joy, pleasure and profit of doing the job, rather than the use which one may have of the finished product." Based on that definition, we have the moon shot, hot shave cream, the old aroma movie, self-defrosting refrigerators, gas refrigerators, fluidics, etc.

2. It is proposed that the SST will make money, that it will help our balance of payments problem, that it will keep the aircraft industry happy, and that it will have some military spillover in case we ever need it.

3. We really haven't settled this one. Its proponents say that the SST will not fly over populated areas. I don't believe them. Most conservationists believe that once these darn things are built, the pressure to fly them over my home will be very great and the pressure to fly them over wilderness areas, where I go to get away from the noise, will be irresistible. Right now in our society we have no procedure for settling such questions; this is one of our real national problems.

4. People with cameras are apparently entitled to go to any sort of place that people without cameras wouldn't. At a recent wedding I saw a man with a camera walk up right behind the clergyman and take a picture over his shoulder during the ceremony. Similarly, reporters and TV cameramen at meetings feel that it is perfectly all right for them to do almost anything while the meeting is going on. People with helicopters have the right to disturb the large crowds of people by flying low over them at any time, including the one who flew low over the University of Utah Library Dedication, and made the whole procedure stop until he flew away because no one could hear. People with motorcycles have apparently the God-given right to tear up any piece of grass that suits them.

   One might also talk here about the involved political-military hassle over who got the SST contract. Basically, there were two final competitors: Lockheed, who had a fixed-wing design and Boeing, who had a swing-wing design. Boeing got the contracts, spent a large amount of the government's money proving beyond any doubt that the Lockheed design was the better one. They are now going to build Lockheed's design. Not much was said about that because apparently Boeing got robbed on the TFX contract and, therefore, were being paid off for it; a lovely piece of American history.

Discussion questions for Jerome B. Wiesner, "Science and Technology," Playboy 16 (Jan. 1969), 90.

He suggests that although science and technology may have greatly contributed to the problems we now face in our society, they now offer the only hope for solving this set of problems.

1. At the end of the first page he talks about the "....alienation of citizens, especially young people, from a highly complex society to which they appear irrelevant." Is this one of the causes of campus unrest and the hippie movement? The main cause?

2. Can you cite any examples of our efforts to fashion the new political and psychological world he suggests?

3. He cites as examples of "technology out of control" the auto and television. These are the ones everyone cites, along with the SST and pesticides. What other one should be cited which does not normally appear on this list? Or is the whole list nonsense in that none of these are "technologies out of control?"

4. He calls for the development of a skill called "social engineering" which will use the combined power of technology, physical and social science to control society's problems. Can this be done without large-scale manipulation of people? Is this something we approve of, or disapprove of, or are indifferent to?

5. Do you think he is calling for new technological research and development, or only the wise use of what is now known? Would he agree with a proposal that all scientists and engineers stop working on new ideas and work full time on the constructive use of the ones we have? Would you agree with such a proposal?

My answers for "Science and Technology."

1. I am doubtful about that and the students in the class seemed doubtful too. However, they are not alienated either, so one really ought to try and get some feedback from the students who are alienated.

2. One might cite the war on poverty as a pretty half-hearted effort. This is the case of the technologists saying that the problem is not technological, but social.

3. Our death control policy, which has led to the population explosion, is probably the most out of control of all and no one talks about that. The other one out of control is probably synthetic chemistry, which is turning loose in the world all sorts of chemicals, which have no way of disappearing because there are no biological agents to get rid of them.

4. No, it certainly involves large scale manipulation of people. It is probably something we should worry about and probably something we have to do.

5. Only wise use. He probably would call for them to stop new work and that is a very debatable proposal.

Discussion questions for J. J. Rousseau, "Discourse On Inequality." The page numbers cited here correspond to those in M. Donner, et.al. "The Intellectual Tradition of the West: Readings in the History of Ideas." Vol. 2, Scott Forseman & Company, 1968.

Rousseau's "Discourse On Inequality" sets forth his belief that inequality among man is a result of property and industry. According to him, before we had organized societies, land ownership, agriculture, and metallurgy all men were equal and happy.

1. Rousseau places considerable emphasis upon the division of land and land titles as being the basic function of human society and the basic cause

of human inequality. Have other, more recent writers agreed with this viewpoint? How could one prove or disprove this viewpoint?

2. What are his views about the history of human development based upon? Have later authors concluded that these were basically correct, or have other viewpoints become more common?

3. At the top of page 228, he makes the basic assertion that material wealth does not bring happiness. Is "Brave New World" just an amplification of the first paragraph on page 228, or are there basically new and different ideas suggested in "Brave New World?"

4. In the last paragraph on page 232, he says that such societies "irretrievably destroyed natural liberty." What is his definition of liberty? Based on his definition, are his previous statements generally correct? What alternative definition would you propose which would make his statements not correct?

My answers to "Discourse On Equality."

1. The most famous recent writers who have taken up this viewpoint are Ricardo, and Henry George. The ideas are probably most thoroughly worked out in George's, "Progress and Poverty." Proving or disproving this would be hard indeed; it seems much more likely to have been true in societies in which wealth was almost entirely derived from land than in societies like our own.

2. His views on history of human development are almost completely based on his own speculations on the subject. Those interested in a contrary view should see the writings of Robert Ardrey, e.g., "The Territorial Imperative." Ardrey's studies of animals would lead one to believe that the desire to have complete control of land is not a uniquely human desire but one we share with many animals. If Ardrey and the others who share his viewpoint are right in this subject, then Rousseau is dead wrong.

3. I think there are basically new and different ideas in "Brave New World." The idea that wealth does not bring happiness is certainly there, but there is also the idea that our technological advances have brought us to a point at which we can no longer allow each individual to proceed his own way. I see very little of that in Rousseau.

4. His definition of liberty must be "complete lack of interference by others in one's life." His statements based on this definition presume that before the inventions of agriculture and metallurgy, such interventions did not exist. This is highly questionable. Among tribes which do not have agriculture and metallurgy there is considerable interference in one another's lives. I would define liberty as the freedom to conduct one's life with the greatest number of meaningful choices as to what courses are to be followed, what actions one may take, etc. Based on that, one would conclude that all of the industrialization and technological advance we have been discussing greatly increases one's list of choices and meaningful opportunities for various life styles, etc., and hence that Rousseau is entirely wrong about this.

IV-A-3. Examination questions for Topic 1

1. Ferry suggests that technological advance "castrates the human spirit." Technology's supporters would counter that technological advance liberates the human spirit. Select one example of some kind of technological advance which you believe either castrates or liberates the human spirit, and write a short but well reasoned explanation of why this particular kind of technological advance castrates or liberates.

2. In the readings which can be considered "the complaints of the humanists" some complaints are really just the opposition of conservatives to any change, and might just as well have been made by someone in the middle ages. Others are really complaints about things going on now which had no counterparts in the middle ages, or other historical periods. (a) Select one complaint which you think is really just conservative opposition to change, and defend your choice by showing that this complaint in some form has existed before. (b) Then select one complaint which is not just conservative opposition, but really is a complaint about something new, and give the supporting reasons and/or examples for this.

3. Write out an acceptable definition of a "technological stunt." Then, based on this definition, show an example of a technological stunt which is basically good, one which is neutral, i.e., neither good nor evil, and one which is evil. Give your reasons, based on your definition, for classifying the stunts the way you do.

4. One of the "complaints of the humanists" is that modern technology has given man more leisure, health, and material wealth, but that this is not enough. Show how the various texts we have read contribute to this theme, either by agreeing or disagreeing with it. Cite specific references, (with page numbers) to illustrate how the various authors react to this idea. (This question is for an open book test.)

IV-A-4. Paper subjects for Topic 1

1. Are the complaints brought by the authors here presented basically new, or are they basically rehashes of the eternal complaint of conservatives that change is bad?

2. Calder proposes that someone should oppose new technologies. Does any new technology come into use without some opposition? For the case of some two major technologies, e.g., autos, railroads, pastuerization, telephones, etc., explore the history of the opposition to its introduction. Discuss how this opposition was overcome. Also, if possible, find an example of a technology which was suppressed by popular opposition, and discuss its history.

3. Calder proposes the politicizing of technological decisions. Prepare a history of technological decisions which were made through open public debate.

4. Ferry says "Technology is the American theology...." Are other nations as infatuated with technological advance as he says we are? Are there critics

of technology like him in other countries? Are there any in socialist-communist countries? (A starting point might be Jaques Ellul, "The Technological Society.")

5. Ferry raises the problem of the SST, and the balance between the rights of the machine-user and those adversely affected by the machine. How are such conflicts currently resolved in our society? What is the history of the resolution of such conflicts? Is there a different history for "environmental effects," e.g., noise, smog, water pollution, and non-environmental effects, e.g., loss of livelihood, direct injuries, etc.?

6. Rickover raises the question of whether technological change should cause change in moral standards. Present a well-documented case of a single technological change causing a significant change in the official position of the government or of a major church on the morality of some act or set of acts.

7. Are there examples earlier than "Brave New World" of social critics predicting very evil consequences of letting the technologists take control?

8. Ferry suggests we must rewrite the constitution to control technology. Prepare a draft of the revised sections of that rewritten constitution.

9. Do the kind of complaints of the humanists which we discussed at the start of this course only occur in capitalist countries, or do they occur in socialist countries too? Examples?

10. In our class discussion we covered the question of whether technological advance has in the past led to increased regimentation of human life, (to which the answer seems to be yes) and whether this is an inevitable connection, or whether in the future it might go the other way. It would be interesting to examine this question in more detail, with examples.

11. I suggested in class that the real message of "Brave New World" is that if you let the technologists take over the result is a world which is destructive of the human spirit. I would like to read a good paper on this subject, which cites examples which either reinforce or contradict this suggestion.

IV-B. Topic 2. The History of Technological Change, the Acceleration of Technological Change and the Transfer of Technology

One of the most significant characteristics of our age is its rapid rate of technological change. This rate of change is dramatically illustrated by the fact that the elapsed time from the Wright brothers' flight to the moon landing was only 66 years. For us, rapid technological change is the normal human circumstance. Throughout most of human history, this was not the case. In most societies throughout history, technological change has come about very slowly and has not been considered an important part of the people's lives.

Because technological change previously came about slowly, it did not attract the attention of the people among whom it was occurring and did not seem to attract the attention of historians. The principal reading of this section is devoted to a re-examination of part of our history, which indicates that the technological changes occurring were very significant in that history, even though previous historians have overlooked them.

A corollary of the rapid rate of technological change in our societies is the problem of the transfer of technology. We now have on this planet societies with extremely advanced technologies living side-by-side with societies whose technologies are basically those of the Stone Age. In earlier ages in which technological change occurred slowly, the new technology developed in one society could spread gradually to other societies and be easily assimilated by them. This is no longer the case. Because we are developing new technologies so rapidly in Western societies, these technologies are transmitted to other societies more rapidly than they can easily adjust to them. This poses some moral and ethical problems for the donor society, as shown in the readings here.

The principle reading for this section is Lynn White, Jr., "Medeival Technology and Social Change," Oxford University Press. This is a fascinating attempt by Professor White to show that technological change did play a significant role in previous history, although that role has frequently been ignored. The orher readings are: Hornel Hart, "Accelleration in Social Change," two stories about poisonings from the New York Times, excerpts from Leonard Arrington, "Great Basin Kingdom," and Drucker's, "The Technological Revolution."

IV-B-1. Discussion questions and answers for Topic 2

Discussion questions for Lynn White, Jr., "Medieval Technology and Social Change," Oxford University Press, 1962. (Available as a $1.50 paperback as well as a more expensive hardbound version.)

This is a brief, scholarly study written by White for his fellow prefessional historians; it turned out to be so interesting and informative that it now has a much wider readership. The main text is only 135 pages long with an additional 40 pages of notes and references. It is somewhat of a disappointment to me, that although I consider this a truly outstanding, fascinating and delightful piece of technological history, it has only a fair response from the students. I consider it a challenge to my ability as a teacher to help the students appreciate this excellent book.

White considers three significant changes in Medieval technology and their consequences. First, the introduction of the stirrup and its revolutionary

effects upon combat. Second, the changes in agriculture brought about by the introduction of the horse-drawn plow and third, the medieval efforts at developing a power technology.

Chapter I

1. Is his turning around of Voltaire's famous statement of page v correct? Or is Voltaire right? Or both?

2. Is his basic idea that the introduction of the stirrup caused the sudden explosion of Feudalism adequately supported by the data he presents for it?

3. He shows in his book that the stirrup was known in other areas before it was known in Europe. It didn't produce feudalism there, but apparently did in Europe. Why?

4. On page 28, he says, "...a new device merely opens a door; it does not compel one to enter." True? Examples?

5. What other technological changes, if any, have had comparably rapid effects on social arrangements?

6. How long did it take to develop an adequate defense against the charging knight? What was that defense? Did it change social institutions too?

7. What fraction of the populace of medieval Europe participated directly in the technological change he describes? What fraction were significantly affected by it?

Chapter II

1. On page 44 he indicates that "surplus food....is the presupposition of population growth...., etc." Is this right? Is it a direct connection; i.e., does surplus food always lead to the things he suggests? Do those things ever occur without surplus food?

2. On page 56 he states that the heavy plow changed man from a part of nature to her exploiter. Is this true? Does he adequately support this statement?

3. On page 65 he cites the peasants' reluctance to work hard on the master's estate, and their harder work on their own. Is there a significant current example of the same kind?

4. On page 68 he points out the benefits of a faster mode of transportation in making "urban" life available to more people. Is there a current parallel to this?

5. One of the current "in" words in engineering and government circles is "the systems approach" which means simply trying to look at all parts of a problem at once. For example, in developing the Polaris missile system one had to develop the missile, the submarine, the underwater launch system, the underwater navigation system and the missile aiming system simultaneously. This was done in about five years. Taking the "systems approach" to the application of horsepower to agriculture, identify the important system-development problems and indicate how long it took to solve them.

Chapter III

1. On page 88 he discusses the use of windmills in Northern Europe; we all associate the windmill with Holland. Were windmills ever widely used in this country? Where? For what purposes?

2. On pages 97 and 101 he indicates that power from combustion and from falling weights was first applied to military purposes where its violence of application was desirable, and only later controlled and put to peaceful purposes. Are there any recent examples of the same kind of history?

3. On page 99 he says, "the metallurgy of the age was not equal to its chemistry." Can you cite any modern examples of cases where one area of technology has completely outrun others, and then had to wait until the others could catch up?

4. On page 101 he talks about the inability to control gravitational power as preventing it from being applied for many years. Is this correct? Was there a form of gravity power in common use by the ancients?

5. On page 102 he talks about the trebuchet as being a substitution of gravity power for manpower. Is this correct? If not, what is the correct statement?

6. On page 115 he summarizes his argument that we were slow to apply rotary motion because it is contrary to what we see and do in organic nature. Is this right? If not, cite examples of rotary motion in living things other than man. If it is right, why are there few or no examples of rotary motion in living things?

7. On page 116 he discusses the introduction of the "ball and chain" governor. What is a governor? Is the ball and chain governor really a governor?

8. On page 128 he describes the two brilliant solutions to the problem of the variable spring tension in a pocket watch. Which of these are used in current watches?

9. At the start of section III, page 129, he poses the question of whether the people of that age were building a solid theoretical foundation for a power technology. Is his answer to that question correct?

My answers for "Medeival Technology...etc."

Chapter I

1. Voltaire is certainly right in what he says, but apparently what White says is right too.

2. I think yes, but this is one for historians to argue about. This is an interesting thing for the students to be faced with, namely a book which is written to convince other historians, something they seldom see.

3. I do not know for sure, but will suggest the following possibilities: First, the previous users of the stirrup were largely from pastoral rather than agrarian societies. In pastoral societies, the population density is much lower than in agrarian societies and therefore, these people may not have

experienced the large-force battles which the people of Europe had experienced. Presumably, the charging knight is more valuable in close combat with large numbers of people than in more spread-out combat which would occur in pastoral societies. Secondly, even if the use of the stirrup for mounted combat was known, it would not be likely to lead to feudalism in pastoral society. In a pastoral society land is not the chief basis of wealth; flocks and herds are. On the other hand, in an agrarian society, land is the chief basis of wealth and the division of land is the division of wealth and power. Finally, for the sudden explosion of feudalism to occur, there must have been available a large amount of valuable land which could be confiscated without serious defense by its owners. This was available in Western Europe in the form of church lands. Perhaps all of these conditions must be satisfied for a radical explosion of feudalism as discussed by White.

4. The stirrup opened the door for many peoples, but the Franks were the first to go through and as he points out, the Saxons suffered because they didn't go through. In military matters, if one knows the door is open and doesn't go through it, he may suffer. For example, the Germans presumably knew the door to the atom bomb was open but didn't go through vigorously enough. Nowadays, we are reluctant not to go through any door for fear that the Russians will beat us through it. One consideration in this whole thing is the question of knowing the door was open. Presumably the Saxons didn't really know the door was open to a superior form of warfare. On the other hand, modern technology has opened an enormous number of doors to different ways of organizing our cities and our daily lives, which by and large we have decided not to go through, mostly by default.

5. The birth control pill has probably had comparably rapid affects on social arrangements. The machine gun certainly did; it changed the whole way of conducting warfare and ended up in practically destroying Europe. The automobile likewise has had dramatic and social affects and perhaps the computer will. One can also argue that the railroad had comparable affects because it changed societies which could not possibly be industrialized to those which could be industrialized quite rapidly. (An interesting sidelight is that the railroad also made professional baseball possible.)

6. Several centuries. The defense was partly the English longbowman, which was successful against the French knights in several crucial battles because the fields were muddy and the archers had the high ground. The most famous of these battles was the Battle of Crecy. It required an organization and training of the English yeomanry, which must have had significant affects on lots of things, including the way private citizens are treated in English law as compared to other laws. Certainly the way we live in this country today has been influenced by the organization of the English yeomanry as longbowmen. The crossbow was also somewhat effective but finally the gun settled things for the charging knight. The gun has certainly changed numerous social relations.

7. Presumably only a very small number of people participated directly in the change because the number of knights was always very small. However, the whole populace presumably were affected by it because it btought about a new system of land tenure and a new kind of local administration.

Chapter II

1. I think it is a necessary but not a sufficient condition. Areas where people didn't have to work for food generally didn't end up being the advanced countries of today, for example, the South Sea Islands.

2. This is a very provocative and controversial statement, which I don't think he backs adequately.

3. This is an obvious parallel to the conflict between the Russian peasants and their communist masters.

4. This is clearly parallel to the effect of the automobile.

5. The bridle and bit, saddle, harness, shoes, heavy plow, feed, veterinary medicine, breeding techniques. It took them several hundred years. Perhaps the more important thing was understanding how to use them; the knowledge and understanding of the technology, which is now referred to as "the software."

Chapter III

1. Some American historians, e.g., Walter P. Webb, "The Great Plains," Blaisdell, 1959, indicate that the settlement of the high plains (Kansas, Nebraska, Eastern Wyoming, Eastern Colorado and the Dakotas), required the windmill, barbed wire and the steel plow. The windmill was needed in order to provide a steady water source from deep wells, which could not be obtained any other way. In Williamsburg, Virginia, they have a beautiful windmill, which they use to grind their grain. In the first part of the southeast to be developed, which consists of drowned valleys which can be navigated by sailing ships, they had no significant water power; they had to depend on wind power to grind the grain.

2. Fission power has already gone that route and fusion power has gone part of it, but it has not yet been controlled.

3. A good example is the speed with which we can process information inside machines compared with the time required to get the information into and out of the machines. I was told by a chemist that the first automobiles had cadmium-plated exterior metal parts, but when alkyd paints became available those began to outlast the cadmium parts and required the switch to chromium plating. Certainly, the early railroads were superior technologically to the material they were using, cast iron, and needed the development of a new material, steel, before they could really get going.

4. Water power is gravitational power.

5. The trebuchet is a concentration of manpower, not a substitution. This is the usual case of a non-technologist missing the technological point; tools do not substitute for muscle-power, they concentrate and direct it.

6. It is hard to find examples. The only one I can think of is the rotating seeds, which fall through the air from some trees like maples. Probably the most difficult problem biologically is that of rotary lubricant seals and of rotary transport of fluids across junctions. Our bodily joints

all allow flexible fluid connections and it would have been difficult to evolve flexible fluid connections for rotating systems.

7. A governor controls the rate of some operations, normally by feedback. This is a governor only in the sense that a fly-wheel is a governor. He does not realize that feedback is the key to governing an automaton.

8. Neither. We have worked up a far better scheme, based on the rotating balance wheel and Newton's laws.

9. No. He is mistaken about this. The quest for the perpetual motion machine is a clear indication of a lack of any theoretical understanding of what they were doing.

Discussion questions for Hornell Hart, "Acceleration in Social Change." This is chapter III of Frances R. Allen, et.al., "Technology and Social Change," Appleton-Centure-Crofts, 1957. Reprint permission for this chapter was obtained at moderate cost from the publisher, the Meredith Corporation.

Hornell Hart presents here his data on the rate of acceleration of technological progress and his beliefs as to why technology is progressing so much more rapidly now than it has in the past.

As the following discussion questions show, I do not think that Professor Hart has all of this material completely and correctly interpreted. However, it is the best I could find on the general topic of why we now have a much more rapid rate of technological change than we had in the past. I will be most grateful to any reader who can suggest to me a more suitable reading for this point in the course.

1. Is this article about social change, cultural change, technological change, or all three?

2. On page 31 he discusses the spear thrower as, "...augmenting the force of the human arm...." Is this really its function? If not, what is?

3. On page 35 he recites a remark by A. L. Kroeber, and then gives his view that Kroeber is mistaken. Does he prove his point, or do you end up believing that maybe Kroeber is right?

4. On page 40 he cites the examples of H. G. Wells' ability to see one part of the future, not others. Cite other examples where those predicting the future have made this kind of error.

5. Is his statement on page 49 that every invention consists of a new combination of old elements true? Only partly true? Never true?

6. The case of Goodyear and the chance discovery of vulcanization is one of the most famous of the "accidental" inventions. List other famous "accidental" inventions. List some important inventions which were the result of planned effort and not accidental at all.

7. In his list of reasons for this acceleration on page 53, does he leave out any important ones?

8. Make a brief list of inventions which were made as a result of social pressure for the particular item. Make a brief list of inventions which were made without such social pressure, but resulted from the inventor's belief that once the thing was offered to the public they would accept it.

My answers for "Acceleration in Social Change."

1. This is mostly about technological change, which makes the title very interesting. He seems to use the worlds technological, cultural, and social almost interchangeably. If one defines cultural broadly enough or social broadly enough so that technological is a subspecies, then this is okay.

2. This is an example almost exactly like the one in Lynn White, where a non-technical person is unable to distinguish between concentrating force and power and augmenting it. Clearly the spear thrower concentrates rather than augments.

3. His response to Kroeber is very, very weak. I think Kroeber has the best of the arguments.

4. We discussed several examples of this type in "Brave New World." It seems clear that in any of the utopias or science fiction stories which project worlds of the future, there will be this kind of error.

   A related kind of error is developing a technology or device for which the market will disappear because of other technological advances. There are numerous examples of this sort, for instance, the development of air-breathing missiles, which was a magnificent technical accomplishment leading nowhere because by the time they were developed, a superior weapon system was around, which made them unnecessary. Another example is that the first really good portable mechanical calculator, the Curta, was developed just about the time the digital computers made it unnecessary. The first good sailing ship, the clipper, came along just as steam outmoded it.

5. I think it is debatable, but one has to agree on what he means by a combination of previously existing elements. If one takes as your previously existing elements the 92 chemical elements of the earth, then certainly everything that is around can be put together by those. If, on the other hand, you mean by elements new thoughts or ideas, you ask yourself what elements are combined to make the wheel or what elements are combined to control fire. I conclude that those aren't necessarily a combination of pre-existing elements. This is again an arguable point for which I have never gotten a very clear resolution.

6. Accidental ones would include penicillin, Teflon, calcium carbide, etc. Planned ones would include nylon, diamonds, modern metals, airplanes, polio vaccine, etc.

7. He leaves out the number of people involved in purposeful effort to find new things.

8. Inventions for which there was a demand include almost all medical devices and inventions, fertilizers, farm equipment, improved aircraft, etc. Devices for which there was no public demand until the device was available would include the auto, most home appliances, most new food products, synthetic fibers, and the like.

Discussion questions for the poison stories (New York Times, Sept. 26, 28, 29 and Nov. 26, 28, 1967). These concern two cases of mass poisonings, caused by accidental mixing of insecticides and foodstuffs.

1. How do we avoid such disasters in this country?

2. Would such prevention methods be easily applicable in underdeveloped and largely preliterate countries?

3. It has been suggested that it would be better for such underdeveloped and/or preliterate countries if we refused to sell to them and highly toxic substances like insecticides until they develop the institutions to protect themselves from the possible ill effects of these materials. What would be the advantages and disadvantages of such a policy?

4. What policies might we follow in the sale of highly toxic chemicals to preliterate countries in order to make accidents of the type described here less likely?

5. Who should assume responsibility for such policies? The technologically advanced nation? The recipient nation? The United Nations? The individual supplier?

My answers for the poison stories.

1. We have fairly strict laws forbidding the transportation of foodstuffs and highly toxic chemicals in the same vehicles or their storage in the same warehouses.

2. We can do this in this country because the vast bulk of our population is literate and we have a large structure of regulatory agencies and bodies to see to it that these laws are obeyed. Since both of these conditions are missing in the underdeveloped countries, it is highly unlikely that these methods could be applied.

3. The advantages are that these poisoning events would no longer occur and the colossal hostility toward the United States which seems to be the inevitable effect of any such poisoning in an underdeveloped country would also not occur. The disadvantages are that the agricultural productivity would fall dramatically and there would be more starvation and perhaps the people would be even more outraged at the United States for not sharing our technology with them.

4. It has been proposed that all highly toxic materials sent to the underdeveloped countries be either dyed with an extremely bright dye or mixed with an extremely powerful emetic, so that the likelihood of these accidents would be decreased. Another possibility would be special kinds of packaging which would be safer than the ones currently used.

5. I would recommend the United Nations or UNESCO or the Food and Agriculture Organization, but this is certainly a debatable point.

Discussion questions for the "Sugar Story," Leonard J. Arrington, "Great Basin Kingdom," Cambridge, Massachusetts, Harvard University Press, copyright 1958 by the President and Fellows of Harvard College, 116-120.

This reading begins at the upper left of the first page with the italics heading Sugar. The book concerns the economic aspects of the LDS Church colonization of the intermountain region up to 1900. It is of special local interest, but possibly of wider interest too.

1. What current world leaders take the same attitude toward developing their native industries that Brigham Young expresses in the middle of the left side of page 116?

2. How should the assembly and start-up problems of the plant have been solved? How are they solved in current plants sold in the way this one was?

3. What lessons could one learn from this enterprise which would be useful to the leaders of the world's current developing countries?

My answers for "The Sugar Story."

1. The leaders of the newly-created countries which were formerly colonies and the newly-nationalistic countries which formerly were effectively colonies of Europe and the United States; for example, the countries of Africa, South America, and Asia.

   President Nasser of Egypt has adopted a similar policy of attempting to produce all basic materials in his country. This led, I am told, to the ridiculous extreme of erecting a steel mill in the country. This mill is very remote from sources of iron ore, coal, and limestone; the freight charges on these raw materials are so high that the total raw materials cost for the plant exceeds the cost of finished steel delivered to the plant site.

2. They should have purchased a plant with guaranteed performance instead of trying to buy it the way they did. That may have been impossible because of transportation problems, but it should have been tried. Once they got into trouble, they should have gotten technical help. Perhaps Truman Angell was right; he was a bright man, but he wasn't trained for the job and he felt that someone trained for the job should have been asked to do it. His remark also suggests that there was no one with clear authority.

   Currently such plants are sold to underdeveloped countries with contracts which include the start-up of the plant as part of the contract.

3. Faith or nationalism is no substitute for technical knowledge. Under-capitalized manufacturing enterprises will not be successful. You have to be patient and willing to consider the consequences of new surroundings on old processes.

Discussion questions for Peter F. Drucker, "The Technological Revolution: Notes on the Relationship of Technology, Science & Culture," Technology and Culture, 2 (1961), 342.

Drucker suggests that the truly revolutionary development in western history was not the emergence of science, but the application of science to technological problems which he says occurred in the period between 1750 and 1800. He cites numerous interesting examples to support this view.

1. On page 347 he suggests that the Mining Academy was called into existence as a result of a single technological change, in this case the Newcomen Engine, which made deep mining possible. What institutions has our society called into existence in the past 100 years as a direct result of specific technological changes?

2. Drucker suggests that there is a confusion between scientific advance and technological advance. Does this confusion exist at present in the USA? Examples?

3. At what point in history (if ever) did the scientific-technological marriage Drucker speaks of become one in which science contributed more than it received? Consider this as separate questions for the following areas: (a) medicine (b) agriculture (c) transportation, (d) warfare (e) manufacturing.

My answers for "The Technological Revolution."

1. The whole regulatory apparatus concerning public utilities, automobiles, airplanes, radio waves, drugs, agriculture, farming subsidies, etc.

2. Yes. We have the whole moon business, which is billed frequently as a great scientific undertaking, but is actually a great engineering undertaking. We have the National Science Foundation, which really supports most of the engineering and technological research in this country; and we have the question of whether the National Institutes of Health should support science or technology or both.

3. In medicine, the change took place after Pasteur, i.e., about 1850-1860. In agriculture, presumably the watershed came with the discovery of the essential elements in fertilizers. I have read somewhere that Leibig did that, but I haven't checked the source. In transportation it is questionable whether science has contributed much at all. During the period when the greatest advances in transportation technology have been made, the scientists have been largely working on an entirely different set of problems and paying no attention to it. One of the most significant contributors to the entire affair was Ford, whose contempt for science was virtually unlimited. For warfare, the watershed seems to have been between the First and Second World Wars. In the First World War, there is the famous story of the American Chemical Society offering its services to the Secretary of War, who wrote back that they wouldn't need them, since they already had a chemist. There is also the famous story of the Government's Board of Scientific Experts, chaired by Edison, who commented that it might be nice to have a mathematician in the group in case they had to figure something out. Things had changed quite a bit on that subject by the Second World War. In manufacturing, science began to be taken seriously about the first of this century.

IV-B-2. Additional Material for Topic 2

Much has been written on the subject of technological history. Perhaps the most comprehensive work is Singer, et.al., "The History of Technology," Oxford. This collection of articles on various subjects is recommended reading for all those interested in the subject. It is unfortunately biased in favor of English technological history as opposed to world technological history. Anyone interested in this subject should also peruse the back issues of "Technology and Culture," the International Quarterly of the Society for the History of Technology. This contains many fascinating short articles. A fine collection of articles of the type which appear in "Technology and Culture" is "Technology in Western Civilization, Vol. 1" edited by Melvin Kranzberg and Carol W. Pursell, Jr., Oxford University Press, 1968.

Another possible source is Gene Ford Brennan, "The Elegant Solution," Van Nostrand, 1967. This is a significantly less scholarly treatment of some modern technological achievements. It is written largely at high school level apparently to supplement the "Man-Made World" course material. The topics covered are (1) the Boeing 707, (2) the nautilus submarine, (3) zerox, (4) trans-atlantic telephone cables, (5) the digital computer, and (6) revolutionary structures. The writing is clear, lucid and interesting, but all of it is written for a high school audience, and therefore, seems inappropriate for college audience. The foregoing are as far as I know only available in hard cover and therefore, probably not suitable as text material.

A possible alternative which I have tried is Lewis Mumford, "Technics and Civilization," Harcourt Brace World, 1934, available in pocketbook from Harcourt Brace at $3.75. This is a very famous book which is widely regarded as one of the classics in the field of technological history. However, after using it as a text in an honors course, I conclude that it is not suitable. Even typical university undergraduates can readily detect that it is full of errors, sweeping unsupported generalizations, and very questionable interpretations. I do not criticize as distinguished a social commentator as Lewis Mumford lightly, but I believe that any technically trained reader will readily detect numerous errors in this book and any reader critical of unsupported assumption will find that the book is full of them. The book has many fascinating ideas and speculations, and some fine prose; it is not good history.

IV-B-3. Examination questions for Topic 2

1. Technological change can come about by local invention of new technology, or by importation of new technology from some other area. Which of these causes the greatest social and cultural change? Support your answer by citing examples of some important technological changes which caused demonstrably greater social and cultural change in the area of invention than in the area of importation or the reverse.

2. Drucker in, "The Technological Revolution" cites the Mining Academy as an institution called into existence as a direct result of a specific technological advance, in this case the Newcomen Engine which made deep mining possible. List five other examples of institutions in our society which were called into existence as a direct result of some specific technological change or group of changes. In each case list both the technological change

and the institution. Then (if you want an A+) suggest another institution which does not now exist and which our society will have to call into existence soon as a result of some recent technological change, and give the reasons why it must do so.

3. Lynn White, on page 28 of "Medieval Technology and Social Change" says, "....a new device merely opens a door; it does not compel one to enter." Is this true? If your answer is yes, show an example of a society for whom a new device opened a door, which they knew was open, and which they decided not to enter. If your answer is no, show an example of a new device opening a door which the society was thereby compelled to enter.

4. In "Technological Revolution," Drucker says, "....the technological revolution has resulted in....a common world civilization. It is corroding and dissolving history, tradition, culture, and values throughout the world, no matter how old, how highly developed, how deeply cherished and loved." (page 348) Explain what Drucker meant by this statement. Then explain why you agree, or disagree, with Drucker. Give some examples and evidence to support your views.

IV-B-4 Paper subjects for Topic 2

1. Report on an example of a technological change which has had as rapid an effect on social or political arrangements as Lynn White, Jr. says the stirrup had.

2. Some anthropologists, e.g., Leslie A. White, "The Evolution of Culture," McGraw-Hill, 1959, Chapter II, indicate that the level of culture is proportional to the mechanical energy available to the society. (I am simplifying here, but I think I have his main idea right.) Lynn White, Jr. in Chapter III of MT & SC hints that the energy was always there, and hence the level of a society is governed by its ability to control energy. Is this the same as what Leslie White says? Or is it a basically different concept? If so, who is right?

3. We discussed briefly in class the question raised in Hornell Hart's paper about Kroeber's argument for the difference between technological and scientific change and other kinds of change. Report on what other scholars have to say on this question.

4. In class we discussed the question Hart raises about all inventions being merely combinations of pre-existing elements, without coming to a good resolution of it. Find out what other scholars have to say on this topic.

5. In an underdeveloped country should the limited available resources be used to develop a complete range of all the learned disciplines, or should some be concentrated on? Which ones? Which policies are the underdeveloped countries now following?

6. Many problems of underdeveloped countries were encountered by the Mormon Pioneers in Utah. The best source I know on this subject is Leonard Arrington, "Great Basin Kingdom," Harvard University Press, 1958. On page 116, et.seq. he describes some of their difficulties with sugar and iron production. He is quite sketchy on the details of why these enterprises failed. Fill in the details.

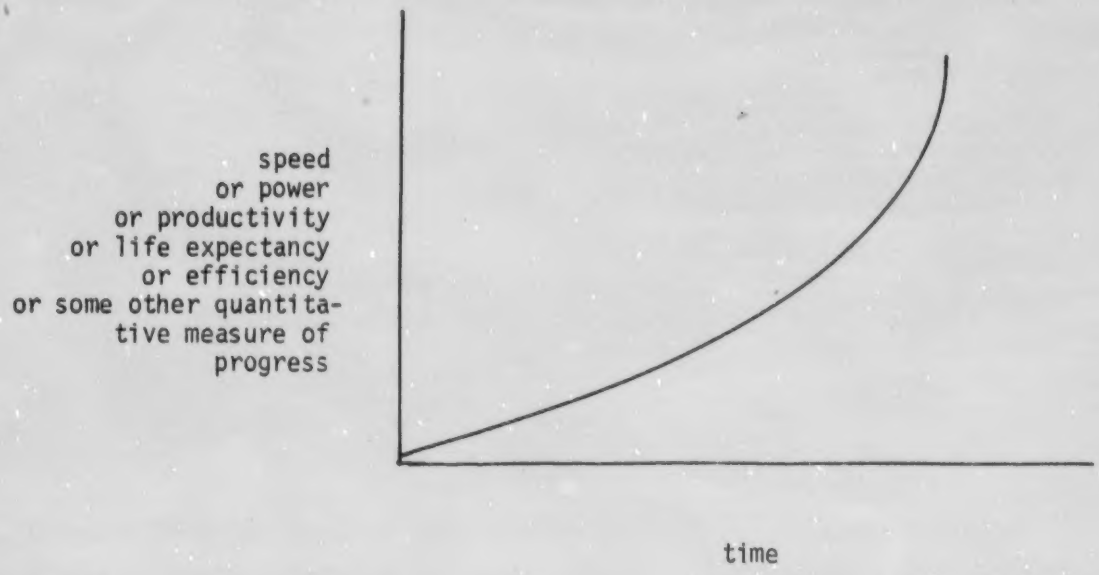
7. Some kinds of technological change are self-defeating. For example, we could never have had atomic power without having coal-based power first. However, atomic power will probably eventually do away with coal-based power. One other possible similar example is the streetcar. The auto has killed it; it might not have been possible to have mass-produced autos without streetcars to bring the workers together. I would like to see a good paper on the case of the streetcar, or any other similar example.

8. One would think that for a given clearly-stated technical problem there would be one solution which is the best. This is often not the case. For example, of the four main ways to organize an automobile (front engine-front drive, front engine-rear drive, rear engine-front drive, rear engine-rear drive) three are currently available for sale in the USA. Why is there no single "best" way to organize an auto? What other examples can be cited of technical problems for which there is no apparent "best" solution?

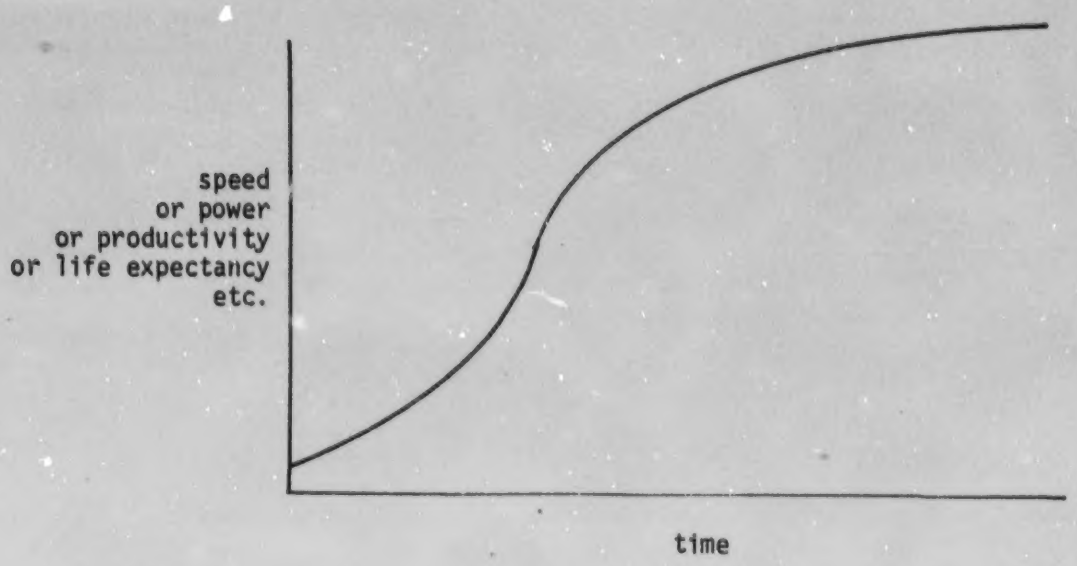
9. Many examples of technological irreversibility are simple examples of population growth being made possible by technological advances, and the increased population making it impossible to return to a previous technological state. Are there examples of technological advances which are irreversible, even if the population remains fixed?

10. Before the war, Japan was a technological imitator. Soon after the war, it became a technological innovator in many fields, and on the whole, is now an innovator. How did this change come about?

11. Hornell Hart, in "Acceleration in Social Change" would lead you to believe that a plot of progress vs. time looks like this:



I believe this may be true for some things, but for others the curve should look more like this:



Find in the library data which will allow you to make up a plot like these for some kind of human accomplishment over a reasonable period of time, and present your plot along with a brief description of your sources of data.

IV-C. Topic 3. How We Respond To Technological Change

Most modern technological change has as its goal improved products or improved methods of producing existing products. As consumers we have always been quite receptive to technological change which gives us improved products or lower prices. Some contend that we now have become so fascinated with technological change and with new products that we will accept whatever is new, regardless of whether it is better. In this section we do not discuss the question of why we prefer that which is better and cheaper; this seems rather obvious. Rather, we examine the negative responses which people have to technological change. The most prominent of these is the violent response of those who see the new machine or new technique as a threat to their job security. The name currently given this response is "luddite." According to the Encyclopedia Britannica the name comes from "King Ned Lud" the pseudonym taken by one of the leaders of a machine-destroying movement in nineteenth century England. That response is shown in the readings here as well as some others.

The principal reading is Elting E. Morison, "Men, Machines, and Modern Times." This book largely devotes itself to the response of the United States Navy to technological innovations during the period 1850-1910. It includes a chapter on the history of the Bessemer process and several other observations. This book contains some truly fascinating history which is told in a charming and interesting way. This history leads to the posing of some important questions about how we ought to respond to technological change. I do not agree with all of Professor Morison's answers to the questions he poses, but I think the questions are very well stated and the examples which raise them are magnificent.

Although the luddite response is probably the most significant one; there are other ways in which we respond to technological change. For example, we tend to worry about the effect of technological changes on our social structure. I consider this the principal reason for the prominence of Marshall McLuhan. This is brought out in the interview with him used as a reading. Similarly, technological change has caused us to shift our viewpoint as to the cause of various troubles which beset us, as indicated in the essay from Time Magazine, "No Way Out, No Way Back." Finally technological change has required us to change our laws as indicated by the insurance readings.

IV-C-1. Discussion questions and answers for Topic 3.

Discussion questions for Elting E. Morison, "Men, Machines, and Modern Times," MIT Press, Cambridge, Massachusetts, 1966.

Morison cites historical examples of the introduction of technological changes and people's response to these. Mostly the response he reports is a negative one in which people fight technological change because it will alter their lives.

In this course we use only chapters I, II, IV, VI, and VIII. Chapters III, V, and VII are interesting and worthwhile outside reading for the student, but have not been used in the course for want of time.

Chapter I

1. On page 9 he says that "....for considerable periods of time before the inventor did his work other men were doing much the same thing." Is that true? Was it true at one time and not at others?

2. On page 10 he lists some examples of resistance of workers to technological change. What other examples could be added to the list?

3. On page 15 he states his belief that the worst problem we face is to fill the gap between the destruction of the old systems and the introduction of the new. Is that right? Examples? Is the real problem something else?

Chapter II

1. On page 19 he proposes that we become an "adaptive society." What are our alternatives to becoming an adaptive society?

2. He cites the Navy as an example of an analyzable society. How good an example of a society is it? What are the significant differences between it and the society of the whole USA.

3. At the bottom of page 34 and the top of page 35 he has a lovely quote about the man raised in sail. Cite other examples in our society in which utterly useless relics of the past are carried along to soothe the sensibilities of those raised in previous eras?

4. On page 38 and 39 he talks about Mahan's quote that services cannot reform themselves, and must depend on outside intervention. Is that true for societies like ours? If so, who should intervene? If not, then is Mahan wrong?

5. On page 43 he has a long discourse about identifying with the processes of society rather than the products. Is he right about this?

Chapter IV

1. On page 76 he cites a provocative quote from E. M. Forester. Do you agree or disagree? Why?

2. On page 78 he says, "All our economic...." Does this contradict the quote from Forester two pages earlier? If so, how does he or should he reconcile this conflict?

3. At the top of page 81 he says (I think) that the Navy was right in defending its internal needs at the expense of lengthening the war and increasing overall American casualties, because its first duty is to preserve itself. Is this a correct paraphrase of what he says? If so, is he right?

4. On page 86 he says we must "find out who we are, and abide by it." Do you agree with that? Suppose we find out that we are racist, materialistic, cruel and ignorant. Should we abide by that?

Chapter VI

1. On page 102 he cites the personal attacks on Isherwood, made in quite biting terms. Does this sort of thing enter current technical debates? Why?

2. On page 105 he cites the attack on Isherwood for printing "mere hypotheses..." Has our view on this sort of thing changed since then?

3. On page 107 he cites our tendency to put a new device into an old setting. Cite examples in addition to the ones he cites here.

4. On page 114 is the beautiful quote about the virtue of sailing ships. Is there any truth in this, or in the comparable one which all parents recite, "When I was a kid we had to..."

5. The Navy, in this case, clearly sacrificed progress and technical efficiency for stability. Is that the right thing to do?

6. On page 120 he asserts that the factory is "the central institution of our society." Is that right?

7. On page 121 he suggests that factories should be restructured so that they are fun for their workers. Do you agree? How much more would you be willing to pay for products produced in such "fun factories?"

Chapter VIII

1. Huxley, quoted on page 208, says, "what are you going to do with all these things?" What does he mean? How should we answer him?

2. Page 211, he says we must fit machines to men, rather than the reverse. Cite examples of cases where we have fit the man to the machine and cases where we have fit the machines to the man.

3. His account of the introduction of pastuerization of pages 212 and 213 raises the question of freedom vs. efficiency. Once the technologists know that something is good, should they be allowed to simply introduce it, or should the people vote, as they voted against pastuerization?

4. Does his proposal to make ours an "experimental society" make sense? If so, do you like his specific proposals or have you others? How shall we evaluate the results of these experiments? Which groups in our society will support this proposal? Which will oppose it?

My answers for "Men, Machines, and Modern Times."

(Note: One interesting sidelight is brought out by Morison's statement on page 9 about the kinds of people who turned out to be creative producers. One wonders how long that has been known in the history of the world. I suggest that this idea goes back at least as far as the Greeks. I do not think it is an accident that the Greeks had Prometheus have his liver eaten out every day; by that time they probably knew that the kind of people who ended up making truly magnificent contributions to the human race were the people who had ulcers.)

Chapter I

1. It is true in many cases; the case he cites about the Bessemer converter is very interesting. I have heard somewhere that the idea of the intra-uterine birth control device goes back hundreds and hundreds of years to Asian camel drivers who discovered that if they put a peach pit in the womb of the female camel, they could then keep her from getting pregnant and could count on her loyal and troublefree service for long trips. It's a lovely story whether it's true or not. In these cases, the inventor merely formalizes and applies what was know before. On the other hand, there are a bunch of recent inventions which simply cannot be fit into that scheme; for example, nylon, the transistor, the laser, the helicopter, the jet engine, etc. One might say that the kinds of inventions he is talking about are those which are likely to be made by people with no scientific understanding; the kinds of inventions that don't fit the scheme he proposes are those which are ultimately based on some kind of scientific understanding.

2. This list is endless. The railroad firemen, the extra men in the cockpit of airliners, the numerous examples of destruction of new machinery by Luddites, etc.

3. I believe that the old system stays on too long; long after conditions have made it impractical. Our problem is to get it out of the way so that we can set up a new system which makes sense in the light of the current realities. Example: The auto made the city-and-county system impossible, but we still stick with it. If we could get rid of it, we might set up a system of government that reflected realities; the atom bomb made the nation-state outmoded and made it really necessary for human survival to go over to a world government. The old governments prevent that. Preventive medicine made high birth rates completely outmoded, but we still seem to be stuck with them. The xerox machine has made the copyright laws outmoded, and we will probably have to change them.

Chapter II

1. A fixed society or a romantic society or a rigidly-structured society.

2. The Navy is caste-oriented and hierarchical. Our society is much less caste-oriented and much less hierarchical. The Navy has a stated set of goals to which it strives. Our society has a much less clearly stated set of goals. The Navy can make appeals to an outside society and is frequently overruled by that outside society. Our society generally does not. The Navy has control of entrance into the society and can expel members who are not congenial. Our society has neither of these.

3. Imitation wood on cars, imitation wood on counter tops and tables, imitation leather in upholstery and clothing, buttons on the cuffs of mens' coats, ties, the current typewriter keyboard, the English system of units, fireplaces in most houses.

4. One hopes not; if anyone is going to intervene, one hopes it will be some benign despot (like perhaps the Almighty). For the Germans in 1945 it was necessary for us to intervene in order to prevent them from continuing an utterly impossible course. We have frequently intervened in Latin America.

One hopes that Mahan is wrong. In some ways, the services have reformed themselves. For example, the submarine and carrier admirals won out over the battleship admirals, although it took them much too long.

5. In a way, the services have done this in their research and development commands. The technological parts of our society have; I think the rest have not. Should we go over to his viewpoint? I don't think the average man ever can come to this, but I hope the intellectuals will.

Chapter IV

1. & 2.
These are a clear contradiction. I think both are overstatements; you can't have it both ways, but I think the latter is more likely to be true than the former. Forester can be defended on the grounds that only individual human beings count, and they don't perceive what is going on. On the other hand, what they do, think, and feel are greatly influenced by other kinds of history, and his view is narrow.

3. I consider this a very provocative question, but the students don't seem to. I vote no; I feel they acted extremely immorally, but then the question is: Am I my brother's keeper? Have I the right to self-preservation even if it means injury and death to others who have in no way harmed me? The Navy, in effect, answered "yes." An interesting sidelight is: If you are willing to accept the Navy's right to cause the death of innocent people (draftees) in order to preserve its own stability and comfort, are you equally willing to agree that American white society has the right to do whatever it likes to our black brothers, in order to preserve the stability and comfort of white society?

4. If he means to find out what the real limitations of human beings and human societies are, fine; I agree. If he means, on the other hand, that we ought to find out what the current average of human behavior is and abide by that, I disagree violently.

Chapter VI

1. Generally these don't come out into the open any more. We live in a more polite era. (People said out loud things about Lincoln which would never be said about Nixon.) Furthermore, such things are likely to be tested and it would be embarrassing to say them and be caught. We are more likely to test now. On the other hand, in closed circles, such things are indeed said; witness the conflict between Teller and Openheimer.

2. The value of the hypothesis has gone up markedly in the eyes of engineers. We now take all the theory we can get, because we have seen its practical value.

3. The first nuclear engines were put in surface-type submarines. Modern heating and ventilating systems are put in old-style houses, rather than being in complete environments. We put modern numbers of students into old-style universities. The first gasoline-powered automobiles were really buggies with engines.

4. Who knows? In the case of the Navy, this was false. Most data which are available today support the belief that today's pampered children are just as strong and healthy as the he-men of my generation.

5. Huxley says that "identity, conformity and stability" are the way to mental stagnation. Morison replies that a too-rapid change is the death of the good life, mental health, etc. Must we choose? Perhaps we have to choose some intermediate course.

6. I consider this pure balderdash. The school, the family, and the boob tube all probably rank ahead of the factory as central institutions.

7. Based on my limited factory experience, I conclude that the people there don't particularly resent the boredom. The trouble must be somewhere else. Many people like a dumb job which doesn't require them to give any thought at all to what they are doing and they will even fight for it. This, in my opinion, is the case of an alpha saying that he would hate to be a gamma or a delta, without asking the gammas and deltas what they think.

Chapter VIII

1. He means that <u>things</u> do not make the good life. True, but the absence of them makes a pretty uncomfortable life. Things open doors. Perhaps we should devote more effort to making people consider the doors which are opened rather than opening more, but I don't want to close any. (Atomic war? yes, I would close that door. Others? No, I don't think I would.) Again, I think that Huxley's comment is one of an alpha protesting that he will no longer have material superiority over the betas, gammas, and deltas.

2. In the old- style production line (e.g., Henry Ford), we fit the man to the machine. In the new ones, we use the man as a watcher. The first computers we ran by fitting the man to the machine; now we have come completely the other way. In the old days, one had to know machine-language programming; nowadays the machines come to your language.

3. Here, the dictatorial rule of the Kaiser prevented needless disease and death. The democracy of England led to disease and death. Was it worth it? Should one be willing to accept needless disease and death as the price of democracy? If one answers yes, then he at least has a consistent position. If he answers no, then should we force fluoridation down the throats of the people? Will we be obliged to force compulsory birth control down the throats of the people?

4. Yes, but only if you can have really controlled tests and wait long enough. Normally this is an impossible condition, because the people in your tests are undergoing all sorts of other tests that you don't know about and you cannot control all the conditions. Furthermore, who is in the position to say that this control group in the slums shall live the straightforward slum life for the next ten years while we try things with other people? Such proposals would have few supporters, perhaps only the social scientists All the establishment groups would oppose it. More frightening, perhaps, is the fact that experiments <u>are</u> being run all the time in completely uncontrolled ways. Isn't the distribution of birth control pills an experiment? Or the widespread use of television?

Discussion questions for Earl D. Johnson, "The Aerospace Industry," in Ginzberg, "Technology and Social Change," Columbia University Press, 1965.

Johnson discusses the aerospace industry, its peculiarities and prospects for the future. Particularly he discusses the problem of the enormous instability of this entire industry.

1. Where does the word "aerospace" come from?

2. Before World War II did we have any vast American industries which sold all their product to the Federal Government, and were entirely dependent on its contracts for their existence?

3. One of the arguments frequently made for the large federal expenditures on space travel is that from it there will be a "fallout" of new technical advances which will enrich the lives of all of us. On page 65 he says that this kind of research involves technology not needed by industry. Does this contradict the above argument? What consumer products or industrial tools have come out of the space program?

4. Is the argument ever made in public policy debate that we have assembled this group of highly skilled people who know how to work as a team and that, therefore, we have to provide work for them to keep them together and working, whether the work is worthwhile by itself or not?

5. Have the big cutbacks and layoffs for technical people which he prophesied here (in 1963) come about?

6. With an industry like this, which exists entirely on public funds, is there ever political pressure brought to bear toward big contracts on some basis other than quality or price?

My answers to "The Aerospace Industry."

1. This is history which I'm not sure of, since it's word-of-mouth history, but my understanding is that that word is a creation of the Air Force Public Relations Department. When the space business and long-range missiles came into being, the question was which service was to dominate it. In Germany, the Army had developed the V-2, which was the best missile in World War II. In the United States, the Army said that a missile like the V-2 is a ground-to-ground projectile following a ballistic course, which just makes it long-range artillery and artillery is a function of the Army. Hence, the Army is the logical one to be in control of this thing. The Air Force said that since it fell from the sky, they owned it. Ultimately, the Air Force won the battle and, therefore, won much of the control of the military uses of space with it. This word was meant to sell the idea that space and air power were synonomous and that, therefore, the Air Force was the logical one to control all space ventures. Ultimately they won.

   Suggested reading here is H. L. Nieburg, "In the Name of Science," Quadrangle Books, Chicago, 1966. This is a sensationalistic, muckraking book about the defense-military establishment in the United States, which is extremely well-documented. I do not assume that it is right in everything it says, but it makes some very challenging and interesting reading. I would like to see a rebuttal, but have not.

2. Not to my knowledge. There were many which were partially dependent; for example, shipbuilding or the small and totally-dependent wood alcohol industry, which exists only because of a quirk in federal alcohol tax law. But there was none like the present aerospace industry.

3. I think it is a complete contradiction. As for the fallout from the space venture, that has been much-discussed, but when one asks for examples, the answers always turn out to be quite thin. (Spacefood sticks? Space blankets?)

4. This is one of the big arguments for the SST. We have a great airframe industry and we have to keep them going; therefore, we should build the thing regardless of its ultimate worth.

5. Largely not. I think the reason we have not had the big cut-backs predicted is because of Vietnam.

6. Obviously. The classic example is the TFX fighter, which was known for mary years around Washington as the LBJ. The contract for it was ultimately awarded to General Dynamics Fort Worth Division.

Discussion questions on the "Playboy Interview with Marshall McLuhan," Playboy, 16 (March 1969), 53 et. seq.

In this in depth interview of Marshall McLuhan, his ideas about communications and changes in communication technology are spelled out in greater clarity and more detail than they are in his books.

1. On page 54, right-hand column, he says he is a generalist, and that his work is a depth operation. Is this a contradiction?

2. On page 56, left column, he says that the content or message of any particular medium has no particular importance. Do you agree with that? If not, supply examples of messages which were presumably important.

3. On page 56, right column, McLuhan discusses what the world was like before the invention of the phonetic alphabet. How did he get this information?

4. On page 60, left column, he says that type is the prototype of all machines. Is this right? If so, what characteristics does it have which win it this honor? If not, what are the other nominees for this honor?

5. On page 61, most of the left-hand column, McLuhan explains the differences between television and media like radio and movies. Is he right about this? What evidence could one present to show that he is right or wrong?

6. In the middle of page 66 McLuhan presents his reasons for racial discrimination. What evidence can be presented pro or con for this explanation?

7. After reading this article do you conclude that McLuhan is: (a) a brilliant prophet of the future, (b) an articulate man who makes interesting speculations about the future, (c) a routine man who has a flair for words, (d) a crackpot, (e) none of the above, but a _____?

8. Why has McLuhan received the prominence he has at this particular time?

My answers to the "Playboy Interview with Marshall McLuhan."

1. I certainly think it is a contradiction.

2. The Bible (Old and New Testament), the Declaration of Independence, the Communist Manifesto, Das Kapital. All of these use the same medium, the printed word. Presumably the content has some effect on what people perceived of them.

3. I think he made it from his fertile imagination. It certainly doesn't fit in very well with what we know about present non-literate cultures. Do we commonly picture the Indian of North America as being primarily an aural being (as McLuhan says), or is he commonly pictured as being one mostly dependent upon his eyes?

4. Mumford in "Technics and Civilization," page 14 has a much-quoted piece on the clock as "the key machine of the new industrial era." He gives a very good defense of his position. It would be worthwhile to review that before discussing this point. I think Mumford is closer to being right than McLuhan is.

5. This appears to be pure balderdash. In the movies and TV the screen is blank for a reasonable period of time. In the movies, it is all blank at once; in TV, it is blank in sections rather than all at once. I don't see where this difference amounts to anything. As to the iconoscope washing our entire bodies, so does the reflected light from the movie screen. In a good TV image, definition is remarkably good. I would suspect that with a really properly tuned black-and-white TV set, one presents an image so good that if a viewer were given one of those to look at and a typical black-and-white movie next to it, he would have no convenient way of telling which was which and probably couldn't perceive the difference. It might be interesting to run such a test. He certainly presents no evidence to support his view.

6. Could he use the same to discuss tribal warfare in Africa or Western Europe's persecution of the Jews, who are presumably the most literate among the Western tribes? I think not.

7. Most of the students agree with me that the correct answer to this is "a crackpot."

8. This is a simple example of a man responding to a need. We are all afraid of the effects of electronic media on us, particularly on our kids, and here comes this man with this amazing verbiage and tells us how it will all revolutionize us. Most of us have not heard much in a scientific vein on this line because those in our society who have tried to do a careful, scholarly attack on this problem with adequate controls and adequate statistical tools have found that the answer is very mixed. One doesn't get a simple sensational result; one finds all sorts of conflicting trends and factors. (See, for example, W. A. Belson, "The Impact of Television," Archon Books, Hamden, Connecticut, 1967.) So if you limit yourself to people who know something about the subject, you don't get anything sensational. McLuhan, therefore, steps into the gap with his sensational remarks not based on any study worth discussing and becomes instantly the prophet.

Discussion questions for Daniel P. Moynihan, "Next a New Auto Insurance Policy," New York Times Magazine, August 27, 1967, and Marc Martin, "The Year of the Plans," For the Defense 10, Defense Research Institute, 1212, West Wisconsin Avenue, Milwaukee, Wisconsin (January 1969).

Moynihan's article shows what he considers to be the serious flaws with the present automobile insurance system used in this country, and discusses the proposals for a superior one. The lawyer's response shows that these proposals will not be greeted enthusiastically by the legal profession.

1. Why do we use the English tort system (i.e., trial based on fault) for the case of auto accidents, and use an entirely different system (workman's compensation) in the case of industrial accidents? Do we ever use the tort system in industrial accidents?

2. On page 62 Moynihan says, "....it is hard to deny the basic rightness of the Basic Protection Plan." Anyone disagree?

3. At the end of his article, Moynihan points out that about one-half of the income of the American legal profession comes from auto accident litigation. Based on this fact, what is the predictable response of the lawyers to the proposal of change in the system?

4. Is the lawyers' reponse as indicated in, "1968, the year of the plans" one of refuting the arguments presented by people like Moynihan? or on some other basis?

5. In "1968, etc.," at the top of the page it says, "We need not put it on the basis of economics. Fortunately there is no conflict of interest here. The lawyer interest and the public interest coincide, etc....." Is this true? How would one show that?

My answers to "Next a New Auto Insurance Policy" and "The Year of the Plans."

1. In the early days, we used the tort system for industrial accidents. As a social decision we stopped using it, because we concluded that it was colossally unfair. In the problem of legal action between the worker who was injured, out of work, and starving and his employer, who had virtually unlimited financial resources and waiting ability, the worker always lost. He had the choice of taking an instant cash settlement of very small value or starving for three or four years until the courts awarded him or his descendants a reasonable judgment. Based on this situation, we added workmen's compensation to the tort situation. This says that regardless of the tort action which may later follow, the person who is injured will be taken care of now. If nothing else, this shows that in the past we have not believed that the tort system was so holy that it could not be tampered with.

2. Certainly there are many people who deny the basic rightness of the protection plan. The second reading is a complete denial of it.

3. The predictable response is the response of anybody who sees a technological change which threatens his way of making a living. He fights it.

4. The lawyers' response is clearly one of an emotional appeal to the precedents of the past, in order to protect the current financial advantages of the profession.

5. I don't think that's true. I don't see why the lawyers' interest and the public's interest coincide in this matter. The lawyers' interest is to maximize their financial returns. I think the public's interest is to maximize the amount of their insurance premiums which go to compensating the injured. It would be interesting to find someone who would try to defend the lawyers' position.

Discussion questions for "No Way Out, No Way Back," Time, (Feb. 21, 1969) 47-48.

"No Way Out, No Way Back" is a one-page essay on the fate of the people caught at Kennedy Airport by a large snow storm. The interesting point is that this was seen by Time Magazine as a "breakdown of the machines."

1. Why is there no subway to the airport in New York?

2. There have been previous groups of people stranded by heavy snowfalls; e.g., the Donner Party. Did the people at the airport suffer more or less than those people did? Did they respond to the situation better or worse than those people did?

3. When only a limited rescue was possible, by helicopter, what means should have been used to allocate that rescue space? Who had a better right to it, those with pull, or those with gall?

4. The writer describing this event looks at it as a failure of machines. What other machines could have failed making the situation worse?

5. Should the airlines be required to keep on hand enough blankets, food, etc., to cover such situations? Would you be willing to pay the increased airline fares this would require?

My answers for "No Way Out, No Way Back."

1. I believe this is mostly a matter of classes. There is one class in America which uses subways and generally does not use airplanes. There is another class which uses airplanes, autos and taxis, but would not use a subway. There are very few U.S. cities in which mass-transit makes direct connection to the airports. I am told Cleveland does, I know of no other example. We seem to have universal agreement that one goes to the airport by taxi or private car. We recently had a study by the Ford Motor Company of a rapid transit scheme from the Salt Lake City downtown to the airport, which was greeted with indifference by the local officials. This business reached its logical conclusion in Los Angeles several years ago, when the traffic jam was so bad on Thanksgiving weekend, that numerous people missed their flights because they were stalled in their cars several miles away.

2. Clearly these people were in excellent circumstances compared to the Donner Party or other groups who were similarly stranded. Their sufferings were trivial compared to those of the other groups. Whether they responded better

or worse, is an interesting question. The Donner Party was stranded for about four months and ended up in cannibalism. Perhaps these people would have done the same, but the test was sufficiently mild that we never found out.

3. This is the classic question: If there is food for one and the second appears, do you feed him and both die, or do you kill him so that you can live? Or, if there is room for ten in the lifeboat and the eleventh appears, do you risk all to bring him in, or do you tell him he has to die now? The world is going to have to think about this a great deal more as the population problem gets to us. Note as an amusing sideline, that Time clearly thinks that it was perfectly all right for the rich man to use his money to buy his way out, but outrageous for those who had gall to use the threat of physical violence to demand their way out too. This goes along with Time's basic orientation, which is that of the white anglo-saxon protestant establishment.

4. We could also have had failure of heat, lights, phone, sewage and power.

5. Most students think not. The question is whether one should socially cover the cost of this emergency by raising the price of airline tickets, i.e., by making everybody take out stranded-at-the-airport insurance, or whether one should let those who are stranded bear the difficulty and inconvenience. The majority vote is for the latter.

In preparing for this discussion, it is interesting to read Life magazine, volume 32, No. 4, January 28, 1952, "An Ancient Pass Traps a Modern Donner Party." This is a description of the Southern Pacific Train, which was caught by a snowstorm going over Donner Summit, in January of 1952, and trapped for three days. I wished to distribute this to the class, but Life magazine denies reprint rights and, therefore, I could not. The most interesting thing about this, is the difference in tone. These people were in much worse circumstances than the people in the airports, and yet if one reads this article one gets the conclusion that here they were in this tough spot but they all pulled together like the good people they were, and ultimately a good time was had by all. The change in tone between that article and the Time article, was one of the most interesting symptoms I have seen of our changing view toward the kinds of breakdown of technology or breakdown of whatever, that is involved in these cases. The point of having this reading here is to show one consequence of technological change; we come to depend on the machines, and to feel lost without them. When something goes wrong, we blame the machines, not "acts-of-God."

IV-C-2. Additional material for Topic 3

In this topic we really spend relatively little time on the matter of technological unemployment. This is probably the best known response to technological change. I assume that the students have already heard enough about that, that we do not need to spend a great deal of time at it on this point. If we wish to spend more time on it, probably the best place to look for information is in the long controversy between the railroads and the railroad unions over how many men it took to run a diesel locomotive. There the issues were extremely clear and straightforward and the battle protracted and well-documented.

A potential additional reading here is Curt Vonnegut, Jr., "Player Piano," Holt, Rhinehart and Winston, 1952, available in paperback. This is a "negative Utopia" placed in the future in which factory automation has gone to its ridiculous extreme and the vast majority of the populace has nothing worthwhile to do. It is in many ways similar to "Brave New World," but in my opinion not as challenging and provocative. If, however, one wished to do a more thorough treatment of the problems of automation this might be a suitable reading.

IV-C-3. Examination questions for Topic 3

1. On page 211 of "Men, Machines and Modern Times," Morison says that we must learn to fit the machines to the men instead of the men to the machines. Cite one example where we have clearly fit the men to the machines, or one example where we have clearly fit the machines to the men.

2. Which technological change has produced the greatest social change in U.S. society in the past ten years? Show in detail what changes it caused.

3. a. On page 10, Morison lists some examples of resistance of workers to technological change. List two further examples.

   b. On page 120, Morison states that the factory is the "central institution of our society." Name at least three other institutions that might be considered even more central.

4. a. In chapters II and IV, Morison analyzes a development in naval technology. The Navy forms a convenient society for analysis. Give arguments why developments in the Navy might not be entirely pertinent to a large society such as the entire U.S.

   b. At the top of page 86, Morison suggests that we "find out who we are, and abide by it." What does he mean? Present an argument against the idea.

5. Morison proposed an "experimental society." What are the characteristics of an experimental society? What steps can we take toward this society?

6. In "Men, Machines and Modern Times" Morison uses several U.S. Navy examples to illustrate how societies often oppose technological change. Briefly summarize two of these examples. Then give an example you know from your own experience of how people tend to resist technological change. Finally, explain your views on whether this tendency to resist change inhibits worthwhile progress, or whether it is a valuable check on runaway technological exploitation.

IV-C-4. Paper subjects for Topic 3

1. At the time of the N.E. power blackout a few years ago, there was much discussion of how people behaved during it. Has that led to any conclusion? From it can we learn anything about how people are likely to behave in the event of future technological disaster?

2. In the early 1960's a process was developed for concentrating beer, thereby greatly reducing shipping costs. ("Chemical and Engineering News," 41; 32, Nov. 18, 1963.) As far as I know, this process was successfully kept out of use by people who saw it as a threat to their jobs. Is this the correct history of the matter? Is this the way the matter should have been settled?

3. In our section of the course dealing with how we respond to technological change, we have seen that most of the examples are examples of people responding to threats to their way of making a living. There are numerous such examples. I would be very interested in knowing what other kinds of response we make which are not connected with threats to our job or the stability of the institution for which we work. Please write a short paper describing some other way in which our society, or people in the society, or people you know or some group within the society responds to some kind of technological change. Give references which show where one could find out more about the subject.

4. Marshall McLuhan has some interesting ideas about the relationship of TV viewers to the TV presentation. Explain McLuhan's position on this question, and his evidence and justification for his position. Then explain why you agree, or disagree, with McLuhan. Give additional evidence and reasons to support your views.

IV-D. Topic 4. The Predictions of Disaster

The principal reading of this section is Paul Erlich, "The Population Bomb." This is a current, widely-read book which predicts numerous disasters in the future based upon scientific and technical computations and the extrapolation of current trends. This type of disaster prediction is now in vogue. In this section of the course we read the main book last. Before it, we read several other scientific predictions, which were demonstrably incorrect. We then analyze these to see how one can be trapped into making such incorrect predictions. After doing that we then consider "The Population Bomb," and ask whether its author has made the same errors that the authors of the previously discussed predictions make. Finally we close with two completely contradictory viewpoints of our future public policy; Garret Hardin's, "The Tragedy of the Commons," and Alvin M. Wineburg's, "Can Technology Replace Social Engineering?"

IV-D-1. Discussion questions and answers for Topic 4

Discussion questions for Thomas Robert Malthus, "An Essay on the Principle of Population, etc." London, 1798. The section which is distributed in the readings is the first 13 pages of the Modern Library edition (Random House, 1960).

Malthus here presents his argument that population will always grow more rapidly than food production can so that we will always have the problem of starvation and misery.

1. As far as I know this is the first of the scientifically or technologically based "predictions of disaster." Can any of you cite an earlier case in which some writer, on the basis of some kind of physical or technological principle, predicted such a disaster?

2. At the bottom of page 9 he lists the inescapable consequences of limitation of food supply as "misery and vice." What does he mean by "vice" here?

3. Is he basically correct in his statement that population, if not restrained, tends to increase in geometric proportion? (Modern writers refer to this as "exponential growth.")

4. Is he basically correct in his assertion that the agricultural productivity of a country, say England, can only be raised in arithmetical sequence as he describes it? Is the same true of the whole world?

5. On the last page he ends this "prediction of disaster" with the following gloomy thought: "....no possible form of society could prevent the almost constant action of misery upon a great part of mankind, if in a state of inequality, and upon all, if all were equal." Has the history of the 170 years since he wrote this proved his prediction correct? If not, why not?

6. In considering his whole thesis can we say that it is (a) completely right, (b) basically right, but perhaps wrong in some details, for example, the time scale over which these things must happen, (c) mostly wrong because he overlooks or leaves out _____?

My answers to the questions on Malthus.

1. As far as I know, this is the first; no one has shown me any other examples.

2. His definition of "vice" is clearly any sexual practice which decreases the number of offspring. I disagree with this definition.

3. I think he is basically correct. The key word here is "restrained." He is correct if we define "restrained" as "restrained in any way."

   When I first gave this answer in a class some of the biology students told me that I was ignorant of modern biology. Modern biological thought has shown that many species limit births by sexually disenfranchising some of the weaker members of the population. In some cases this is due to a clear limitation in the available territory or the available food. For those cases we would certainly say that there was an external restraint. On the other hand, there are some cases in which one cannot show clearly what the limitation is. One may speculate in these cases that there is no restraint and that this is simply a natural self-limitation of population growth; I doubt this and suspect that there is a restraint of some kind which we are not yet able to detect. For readers who wish to explore this point further, I recommend Robert Ardrey, "Population," Life, 6 (Feb. 20, 1970). For a more detailed discussion see Robert Ardrey, "African Genesis."

   Subject to the foregoing caveat I still believe that Malthus is correct; if there is no restraint, then populations tend to grow exponentially.

4. He may be right about England, but he certainly wasn't right with regard to the world. Large land areas were brought into grain production shortly after 1798, namely Canada, United States, Australia and Argentina. Also, he was writing at a time when we were on the lower part of an "S" shaped growth curve. We may be now approaching the top of that, at least in technically-advanced areas. The proponents of "The Green Revolution" dispute that.

5. His prediction has certainly not come true. The main reasons are that: (a) better means of birth control were introduced, (b) much greater agricultural productivity was achieved, (c) new lands were brought into production.

6. Probably he is right, except for the time scale. However, he is wrong in defining birth control as vice.

Discussion questions for Sir William Thompson (Lord Kelvin), "The Doctrine of Uniformity in Geology Briefly Refuted," in Lord Kelvin, "Popular Lectures and Addresses," Vol. II, McMillan & Co., New York (1898), 6-8. (Paper first presented in 1865.)

Kelvin shows in two pages why the earth cannot conceivably be nearly as old as geologists teach us that it is.

1. This short piece by Lord Kelvin, one of the top physical scientists of his day (if not the top physical scientist) is part of a larger controversy which was raging through English, American and European intellectual

circles at the time (1865). What was that controversy and what part was this article intended to play in it?

2. Based on the simple calculation he shows, one can rapidly calculate that the whole earth is cooling at the rate of about 1°F per million years. From this calculation one can work backwards to show that 100 million years ago the whole earth must have been about 100°F warmer, and that life as we know it must have been quite impossible. Yet, geologists inform us that fossils have been found in rocks at least 3.2 billion years old. How is this contradiction to be resolved?

3. Based on the answer to #2, what implications can we draw for other such calculations made by the leading scientists of our time?

My answers to "Doctrine of Uniformity."

1. Clearly this bears upon the Darwinian revolution. Kelvin is on the side of Darwin's opponents. By preparing this article, he was attacking Darwin, indicating that there had not been time available for the evolution Darwin discussed.

2. Kelvin is completely wrong in the conclusion he reaches here. His calculations are wrong because he does not take into account the heat generated in the earth by the radioactive decay of naturally occurring radioactive elements. He does not take this into account because it was completely unknown at the time he wrote this article.

   In writing the article he considered all the known energy sources. However, this energy source is far more significant than other conceivable sources of thermal energy in the earth, because this is energy produced by the conversion of matter to energy. This is a much more powerful source than combustion, chemical reactions, etc.

   If one multiplies the amount of radioactive materials in typical granite by the amount of granite on the surface of this planet and by the energy production per pound of radioactive material, one computes a heat production roughly equivalent to the heat loss calculated by Kelvin. Therefore, as far as temperature is concerned, the world is more or less in steady state.

3. The conclusion is that any calculation based on the laws known at a given time has in it the assumption that there are no other important laws not yet discovered. This is a risky assumption, which most scientists would be afraid to make. I am inclined to guess, however, that none as important as radioactivity and $E=mc^2$ are yet waiting to be discovered; I recognize this is a very hazardous guess.

Discussion questions for Simon Newcomb, "The Outlook for the Flying Machine," The Independent 55 Part 2 (Thursday, October 22, 1903), 2508-2512.

Newcomb shows why it is unlikely that powered, manned flight will be possible in the foreseeable future.

This article appeared about two months before the Wright Brothers first successful powered flight. The author is described as follows in "Memoirs of the National Academy of Sciences Vol. 17 (1924) 23:

"Simon Newcomb was one of the notable scientists that America has ever produced and no other among her men of research has ever achieved such general recognition of eminence...."

1. He proposes on the second page that there are some problems which can never be solved. Is this true? If so, give an example, either from mechanics or mathematics.

2. On the fourth page he points out that there seems to be better prospects for the rotary-winged aircraft, (i.e., the helicopter) than for fixed-wing aircraft which fly forward through the air. Historically, did aircraft develop this way? Why?

3. Is his discussion of the effect of changes in size on the performance of flying machines correct? How large is the largest flying bird? Why are there none larger?

4. His basic prediction here was demonstrably wrong. Why did he make it? How did he fall into this error? What lessons can we learn from his mistake which will help us avoid making similar ones?

5. I first came upon this article by reading the following in Arthur C. Clark, "Next - Planets," Playboy 16, #3 (March 1969):

> "Soon after the failure of Samuel Langley's "aerodrome" in 1903 the great astronomer Simon Newcomb wrote a famous essay, well worth rereading, that proved that heavier-than-air flight was impossible by means of known technology. The ink was hardly dry on the paper when a pair of bicycle mechanics irreverently threw grave doubt on the professor's conclusions."

Is this an accurate description of the article, and of the history of that event?

My answers to "The Outlook for the Flying Machine."

1. In mathematics, one can readily show that the squaring of the circle, or trisection of the angle are impossible. Here, what we really mean, is impossible, subject to a well-defined set of rules. In mechanics, we would say that perpetual motion machines of the first and second type are impossible. Again here, this means types of machines according to well-defined sets of rules. It is hard to think of an example where one can show that something is impossible, in very broadly defined terms, with no specified set of rules.

2. It did not develop that way. If he did a simple energy and momentum balance for these machines, he would have known that the helicopter was basically a much more difficult device than the fixed-wing machine. (See de Nevers, "Fluid Mechanics," Addison-Wesley (1970), 242.

3. He is completely correct here. The largest flying bird is apparently the California Condor, which is really a soaring bird; all large birds are soaring birds rather than flying birds. The reasons are discussed in beautiful detail in J.B.S. Haldane, "On Being the Right Size," in "Possible Worlds and Other Essays," Harper & Row, New York (1927), reprinted in J. R. Newman, "The World of Mathematics," Simon & Schuster, New York (1956).

4. He has hidden assumptions. His worst assumption is that no lighter-weight power source will be developed; this was simply wrong. He also has some bad guesses about what kind of structural materials will be used, and about the difficulty of the control problem. The lesson one can learn is to be careful to look for hidden assumptions.

5. No, that is very bad history. In the first place, Newcomb really only speculated rather than proved, that flight was impossible by means of known technology. Secondly, to call the Wrights "bicycle mechanics" is nonsense. The Wrights were the outstanding Aeronautical Engineers of their day; they had very thoroughly researched the subject. See H. O. Fuchs, "The Wright Brothers' Airplane: A Case History in Engineering Design," UCLA Engineering Department Report, #2-64. (Available through Stanford Engineering Case Library.) Anyone who reads this report will laugh at calling the Wright Brothers "bicycle mechanics." See also section IV-H-1 of this report.

Discussion questions for Paul R. Erlich, "The Population Bomb," Sierra Club, Ballantine (1968).

Erlich shows why increasing population and increasing technology can lead to disaster.

1. Is this work basically scholarly, argumentative, propagandistic, or what other adjective might one use?

2. The previous predictions of disaster we considered, all were incorrect because of various kinds of errors. Does this book fall into the same errors?

3. This book would lead you to believe that population is the problem. Is that right? If that is not right, what is the problem? Does it make any sense at all to speak about there being one problem so much more important than others we would call it the problem?

4. On pages 33-35 he gives what might be considered an up-dated version of Malthus' arguments. Malthus' arguments were presumedly wrong, at least as far as the time scale is concerned. Are his wrong or likely to be wrong, or was Malthus really right?

5. On page 51 he cites one of the hazards of the careless use of DDT in creating instant pests. Another problem with DDT is that it finds its way into human beings. Recent studies indicate that the milk produced by most human females to feed their children contains more DDT than is allowed by the FDA regulations for cow's milk. Why do human females have more DDT in their milk than cows do?

6. At the end of Chapter I he lists numerous problems we face and reduces them all to one -- too many people. Are there any serious problems we face which are not the result of too many people and would be the same if we did not have a growing population?

7. On page 78 he begins his third scenario, which he considers as cheerful a scenario as makes sense. Can you propose a more cheerful scenario which makes sense? Are the actions taken by the United States and other industrialized countries in scenario No. 3 morally acceptable or not?

8. On page 112 he says the only long term direction for the automobile industry is to move to different sources of power. Is that right? Is there any way that the present type of automobile could be preserved in the long term through some kinds of improvements?

9. On page 120 he cites the example of the fire ant program of the U.S. Department of Agriculture, in which they acted not only as one of the principle protagonists but also as the referee who sets the rules for what is an acceptable amount of these materials in the environment. Are there other examples in our society where the same agency is one of the principle causes of environmental pollution and the setter of standards and measurer of performance?

10. On page 132 and the succeeding pages, he cites some possible population control policies for the United States. Are these likely to be acceptable to the people of the United States? If not, what population control policies would be acceptable? Or must we conclude that it is impossible for the people of the United States to accept any reasonable set of population control policies?

11. He points out that our national economic growth is to a large extent based on population growth. Can we have a growing economy and prosperity without population growth? Is population growth good economically for the United States? Is it good economically for Utah?

My answers for "The Population Bomb."

1. I believe this is basically a propagandistic work.

2. In his final chapter he considers the possibility that he is in error about this and throughout seems to take account of the fact that he is talking about what we now know, so that he is at least more conservative about not getting caught in these errors. None of the students could show an example of the kinds of errors discussed.

3. He may be mistaken in saying it is <u>the</u> problem although, after the Honduras el Salvador War of 1969 (which was largely a result of population pressure), we may conclude that it is indeed <u>the</u> problem. However, one can argue that nuclear disarmament is our most pressing problem and that a nuclear war in the near future would probably not be started by population pressure, but by some other conflict.

4. I think he is really giving Malthus' arguments over again and that Malthus was really right except as far as the time scale.

5. Human females eat fat; cows don't eat fat. DDT concentrates in fat.

6. Probably nuclear disarmament.

7. One of the real difficulties here is that by our technological intervention in the lives of these people, through death control, we really set them on their path, which ends up in the horrible scenario he predicts. Under these circumstances it is difficult to say that what we are doing is morally acceptable, but I really have no alternative proposal. I certainly don't have a better scenario.

8. We could indeed keep on burning hydrocarbons if we wanted to, we would have to synthetize them ultimately in nuclear power plants, but that is certainly possible, and maybe even economically feasible. I consider the pollution problems soluble, if we make the required effort.

9. The most blatant example is the AEC, which is the principle radioactive polluter and the setter of standards in this area. There may be others; Bureau of Reclamation? FAA?

10. Probably these are not acceptable to the people of the United States. What we really need now is the colossal propaganda effort, which he is starting, to get people ready to accept these things as soon as possible.

11. This is not known. I think the answer is no. For Utah, the population growth is obviously disastrous, because it means we educate people at great expense and then export them to other states where they spend their adult lives. This places a severe tax burden on the state.

Discussion questions for Garrett Hardin, "The Tragedy of the Commons," Science 162 (Dec. 13, 1968), 1243-248.

He proposes that we must radically change our ideas about common property and the use of environment if we are to survive.

1. Weisner and York present their conclusion that this dilemma has no technical solution. How can this position be justified? Can you propose a possible technical solution to the problem which would show they are mistaken?

2. In the lower right hand side of page 1244 he concludes his discussion of the herding with the statement "Freedom in a Commons brings ruin to all." Has any situation similar to the one he described ever occurred in Utah? How was this situation ultimately resolved?

3. In describing the case of the parking meters in the upper left corner of page 1245 why does he describe this as a retrogressive act?

4. Can no one think of a better solution to the problem of Yosemite National Park than the one he lists here?

5. His statement in the rightmost column of page 1245 "the morality of an act is a function of the state of the system at the time it is performed," appears to be in direct contradiction to the position advocated by H. Rickover that changes in technology ought not to affect changes in morality. Is this a contradiction? If so, who is right?

6. In the lower left hand corner of page 1246 he cites the problem of a family, religion, race or class that adopts overbreeding as a policy to secure its own aggrandizement. Have we seen any examples in recent years where a minority group in a country by breeding more vigorously than the majority group bred its way into political power?

7. His ultimate conclusion is no technical solution can rescue us from the misery and overpopulation. This is obviously a very important statement

and not one to be accepted without being examined at length. If you feel he is mistaken, propose what kind of technological solution, however far out, might occur which would indeed save us from the problem of overpopulation without requiring vast changes in our social and political organization.

My answers for "The Tragedy of the Commons."

1. I think they are wrong about this because what they mean is no technological solution within currently foreseen approaches. If one could indeed develop an absolutely impregnable defense against nuclear weapons, this would be a technological solution. At the moment, we have no idea how to do that, but one would only at great risk predict that we will never know how to do that. We have developed a defense against every previous weapon; perhaps we will against this too. I hope so.

2. Clearly this applied in the case of the beginning of grazing in Utah where we destroyed range land by simple stupid over-grazing; the problem was ultimately solved just as he says, by eliminating the commons in range land.

3. Eliminating the parking meters went back to the commons in parking with the dismal results which inevitably followed.

4. The problem in Yosemite, at least for the near future, is the car, and the solution is very simple. Eliminate the car. Make people park outside and take busses in. In the summer of 1970 the NPS began to do just this.

5. If one defines morality to be a very broad set of guide lines, such as, "avoid injuring other people," then Rickover is certainly right. If, on the other hand, one defines morality in detailed ways, such as; it is never right to kill a buffalo merely in order to eat his tongue, then Hardin is right and Rickover is wrong.

6. In Belgium and/or Holland the Catholics have bred their way into a political majority, which they didn't have before.

7. If we could develop the contraceptive pill, which was a delight to take, and had all sorts of additional side benefits so that one needed enormous self-denial to stop taking it, that would indeed lead to the technological solution to this problem, without a change in beliefs, customs, etc.

   A reply to Hardin is given in Beryl L. Crowe, "The Tragedy of the Commons Revisited," Science 166 (Nov. 28, 1969), 1103. After reading it I do not know which of the protagonists to believe.

Discussion questions for Alvin M. Weinberg, "Can Technology Replace Social Engineering?" Bulletin of the Atomic Scientists 22 (Dec. 1966), 5-8.

He suggests that it is futile to try to solve our really pressing problems by changing people's attitudes, beliefs and customs, and that, therefore, our best course is to try to find technological solutions for social and political problems.

1. On page 5 at the left he points out that numerous projects are relatively easy "once one understands the scientific principles that underlie them."

Is this true? Cite examples in which the scientific principles are known, but yet the problem proved intractable. Cite examples when the big push was made when the scientific principles were not known with or without success.

2. Is his statement that "the Marxist dogma is typical of the social engineer," correct? If not, what is the typical approach of the social engineer? Who are social engineers?

3. Is he right in his suggestion that Edward Teller has contributed more to world peace than Jesus Christ?

4. Is his statement on page 6 that "every water shortage was to be relieved by stealing water from someone else who at the moment didn't need the water or was too weak or too poor to prevent the theft" correct? For example, who owns the water in the Columbia River? Does it belong to the people of the states of Washington and Oregon or does it belong to anyone who needs it or does it belong to the people of the United States or to whom?

5. He says the cost of water acceptable for agriculture is 10 cents a thousand gallons. Is that what agricultural water costs in the Salt Lake Valley now?

6. On the last page he suggests for $4 billion we could provide enough capacity to feed 10 million new mouths. This comes out to be $400 per mouth. Recent studies for underdeveloped countries suggests that the cost of preventing one birth is roughly $5. Which is the more economical way for us to use our money? Which is the more moral way?

7. This article and the one preceeding by Garret Hardin appear to be in direct contradiction. Can this contradiction between them be resolved or can only one of them be right? If so, which if either is right?

My answers to "Can Technology Replace Social Engineering?"

1. Yes, and no. We thought we knew the scientific principles for controlled nuclear fusion, but it turned out to be intractable. We certainly didn't know the scientific principles for the big cancer push and it hasn't been successful.

   The common understanding of Edison's work would lead one to believe that he didn't know the principles, but accomplished the results by trying everything; for example, he has said to have made thousands of experiments before he found a suitable lamp bulb filament, and when he was done he probably had no real understanding of why this one was better than the others. Similarly he was said to have made thousands of experiments before coming up with his successful storage battery system. However, as one looks into some of the things he did, one concludes that he did indeed study and understand many things. It is reported in some biographies, for example, that when he decided to set up the electric light business he first studied his competition (the gas-lighting business) to the extent that eventually he was the world's leading expert on the gas lighting system.

Similarly in much of our drug research it seems clear that we do not know in any real detail why many drugs work, we simply synthesize interesting-looking compounds and try them. Once we have found one which seems to have some beneficial effect we then synthesize all the close chemical relatives and try them, thereby working our way toward the most effective one. One can argue whether this is scientific understanding or simply systematic exploration with a limited amount of scientific understanding.

2. The social engineer is really his straw man for people who wish to accomplish results by changing people's customs, beliefs, or attitudes. This is what all religious leaders try to do so that one could say that religious leaders are social engineers. In a way, Garrett Hardin is trying to do this.

3. If this doesn't lead to a free-swinging class discussion, the students are unconscious.

4. Here we have the problem of the two kinds of water law; the eastern "riparian" system and the western "first-in-use, first-in-right" system. The people in Washington and Oregon are going on the former, those in California the latter. We have to decide in the near future.

5. He is high by a factor of ten there.

6. Which is more economical is clear -- I think the more economical is the more morally right.

7. Emotionally I am with Hardin, but practically I think that Weinberg may be right.

Weinberg gives an expanded form of this paper as "Social Problems and Socio-Technical Institutes" in "Applied Science and Technological Progress," a report to the Committee on Science and Astronautics of the U.S. House of Representatives by National Academy of Sciences, June 1967, Government Printing Offices, $1.50. The expanded form is more detailed on some of the questions raised above.

IV-D-2. Additional material for Topic 4

At one time I used as a reading for this course G. O. Smith's "A Foreign Oil Supply For the United States," Transactions of the American Institute of Mining and Metallurgical Engineers 65 (1928), 89, et.seq. This article estimates that the total recoverable oil ever to be found in the United States is of the order of eight billion barrels. Based on this estimate it concludes that within a period of perhaps five years (i.e., by the late 1920's) the United States will be essentially out of oil and ought to be conserving its oil supply for use as a lubricant rather than wasting it as a fuel. This is of course a very bad prediction. Unfortunately the article gives so little detail about how the prediction was made that it does not turn out to be good illustrative material. I have tried to trace down the source of this estimate without much success. If the source of the estimate could be found it might be a very worthwhile material to include in the course.

Another source which is not complete enough to be used directly as class material but which is an interesting starting point for tracking down class

material is Nancy T. Gamarra, "Erroneous Predictions and Negative Comments Concerning Exploration, Territorial Expansion, Scientific and Technological Development: Selected Statements," The Library of Congress Legislative Reference Service, Washington, D.C. Document CB 150 F 381 (May 29, 1968), revised. This contains numerous obviously incorrect predictions; perhaps the most famous is the one on page 40 which I quote, "Admiral William Leahy told President Truman in 1945, 'That is the biggest fool thing we have ever done. The (atomic) bomb will never go off and I speak as an expert in explosives.'" This document contains numerous similar predictions which were disproved by history. For each of these a reference is provided so that the energetic student may track them down to the original source.

Another controversy which one might wish to enter in a scientifically oriented class would be the one over cloud seeding. A starting point for this is Myron Tribus, "Physical View of Cloud Seeding," Science 10 (April 1970). In this article he cites the article with whose predictions he is disagreeing.

Also, for a more technically-oriented version of the course one could use J. W. Campbell, "Rocket Flight to the Moon," The Philosophical Magazine and Journal of Science, Vol. 31 #204 London, Edinburough, and Dublin, (Jan. 1941), 24-34. In this paper Campbell proves that for a reasonable set of assumptions the initial mass of a rocket which is to go to the moon and return must be 2×10^9 X mass of the final rocket which returns to the earth. Thus for a 500 ton returning load the initial rocket would be roughly five miles in diameter. The mathematics are, as far as I can tell, correct; the assumptions are very, very wrong.

An additional prediction of disaster is one concerning the availability of nitrate fertilizers. This is one for which there exists a folk myth in relatively common circulation as follows: Sometime in the late 1890's or early 1900's a very prominent scientist predicted that once the Chilean nitrate beds were exhausted we would face mass starvation on this planet because the source of nitrogen fertilizer for growing of wheat and similar grain crops would no longer be available. Thus, starvation was imminent in the near future. Thus ends the folk myth. I have attempted to track this folk myth to its source without much success. I did, however, find what must be the original source which is W. Crookes, "Presidential Address to the British Association for the Advancement of Science," in "Report of the 68 British Association for the Advancement of Science," 1898. In this article Crookes indeed points out the problem with the exhaustion of the Chilean nitrate beds. He also points out the serious difficulties which would result for the wheat-growing nations of the world if we had no source of nitrates. However, he then continues to show that one solution to the problem is the fixation of atmospheric nitrogen by the Birkland-Eyde electrochemical process. He shows that the required electrical energy is large, but not impossible. He then ends by proposing that chemists devote their efforts to trying to work out better processes, which is precisely what Fritz Haber did. This one is interesting, not only as a "prediction of disaster," but also as an example of how the folk myth can sometimes run away from the facts.

An additional article one might use is the one cited in the "Tragedy of the Commons," namely, Jerome B. Weisner and Herbert F. York, "National Security and the Nuclear Test Ban," Scientific American 211 (Oct. 1964), 27 et.seq. One drawback with using Scientific American material is that one must purchase

reprint rights or purchase offprints and cannot reproduce these inexpensively. However, this is an interesting article which I believe (as discussed in my comments on the "Tragedy of the Commons") does contain some hidden assumptions. However, in reading it one quickly sees that it is directed to a specific political question of the day rather than a general scientific prediction.

IV-D-3. Examination questions for Topic 4

1. List two basically different kinds of errors made by the authors of the "bad predictions" we considered, and cite examples from the readings of these two kinds of errors.

2. Cite a currently unsolved social or political problem for which you believe a "Technological Quick Fix" is possible, and outline the form that "Technological Quick Fix" should take.

   OR

   Cite a currently unsolved social or political problem for which you believe there can never be a "Technological Quick Fix" and give your reasons for so believing.

3. On page 78 of the "Population Bomb," Erlich presents his Third Scenario, which he considers as optimistic a scenario as one can realistically assume. Write what you consider is a realistic scenario which is more optimistic than his third one, and list the actions which the U.S.A. or the U.N. or whoever you consider responsible, must take now to make your scenario come true.

4. Currently, In Utah, there is a noisy conflict between the Governor, the Legislature, and the medical profession over the problem of providing medical care to the people in the rural areas of Utah. Is a "technological quick fix" possible for this problem? If so, show what form it should take. OR Is this a problem which we ought to solve by "social engineering?" If so, show what form of "social engineering" is required. Which ever answer you give, show why your answer (TQF or SE) is better or more reasonable than the other.

5. Is it ever safe to predict that some technological feat can never be accomplished? If not, why not? If so, under what circumstances can such a prediction be justified?

6. In "The Population Bomb," Erlich cites the triage concept of military medical service: When casualties swamp the dressing station, they are classified into three categories. There are those casualties who will recover regardless of the treatment, those who will not recover even if treated, and those who will recover only if treated. Assistance is given to those in the third category. Erlich suggests we consider giving aid to developing countries according to this principle. In fact, this seems to be the policy of our AID program today.

   Assume that the U.S. cannot or will not give enough aid to all of the developing countries to assure continuing development. Do you think the triage

concept is a realistic one in deciding which countries to help? Explain why, or why not. How does this idea compare with Snow's concepts of foreign aid? (Since Snow is read in the sixth topic, this last part of the question can only be used in a final examination.)

IV-D-4. Paper subjects for Topic 4

1. A recent article ("Engineer," Sept.-Oct., 1969, 11) cites data which are interpreted to indicate that nuclear testing has had a significant effect on infant mortality. Present a critical review of that article and the data cited, indicating if the case is adequately supported, or whether there are other possible explanations.

2. It has been claimed that there are important social problems which have no technological solutions. Historically many things have been said to be impossible, only to be made possible by some "technological breakthrough." How are we to evaluate the suggestion that for some important problem there will never be a "technological breakthrough?"

3. Take a "small technology," such as the home laundry machine, typewriters, air conditioners, etc. Trace its development in time from a reasonably early origin to present models, identifying the improvements which have been motivated by common appeal, those that are really "sales gimmicks," those that were introduced toward economy, etc. What long range deleterious effects can be ascribed to this technology; could they have been foreseen earlier and could they have been prevented or avoided if foreseen?

4. In "The Tragedy of the Commons," Hardin defines a class of problems for which he says there are no technical solutions. Yet, in "Can Technology Replace Social Engineering?" Weinberg cites several major social problems which he thinks have been largely solved by a quick technological fix.

   Your assignment is to critically examine these two papers and take a stand on one or the other, or somewhere in between. Give some examples which back up your point of view. Explain carefully why you agree, or disagree with these authors.

IV-E. Topic 5. The Interrelations of Technology

One of the "in" words these days is "ecology" which means considering the interrelations of all of the living things in a given area. An example is given in the following quote from the Associated Press, printed in the Salt Lake City Tribune, Nov. 12, 1969.

> "Look for example, to Borneo where the World Health Organization once used DDT to kill off malaria-carrying mosquitoes.
>
> Not Roaches
>
> It killed the mosquitoes, but it didn't kill roaches, which accumulated DDT in their bodies.
>
> Long-tailed lizards, called geckoes, that roam the walls and floors of tropical houses, ate the roaches, as usual.
>
> But the DDT from the roaches hit the nervous system of the

lizards. They slowed down, became less agile. So cats caught them easily and ate them.

The cats died from the DDT in the lizards.

Rats started moving in from the Borneo forests, carrying the threat of an epidemic of plague.

Catch Rats

So cats were flown out and parachuted into the villages to catch or drive away the rats. They did.

But then the roofs of houses started caving in. The lizards, you see, had also been eating catepillars that made their meals from the roof thatching.

This story is told by Dr. LaMont C. Cole of Cornell University, an ecologist, a specialist studying nature's balance of living things and systems."

The above is an example of a technological change upsetting an ecological balance with the disastrous results described. Similarly, technological changes can cause significant changes in human societies and changes in one technology can cause changes in other technologies. The purpose of this topic is to introduce the students to this idea and show some examples where changes in one technology had far-reaching effects not only in that technology but in other aspects of human society.

The principle reading is "Science and Technology and the Cities: A compilation of papers prepared for the tenth meeting of the panel on Science and Technology of the Committee of Science and Astronautics of the U.S. House of Representatives." This inexpensive paperback contains ten interesting papers, some of which point up clearly the kind of technological interrelations which are the subject of this topic.

The other readings are "Lead Poisoning and the Fall of Rome," which suggests that a simple technological change in Roman society was one of the principle, if not the principle cause of the decline and fall of the Roman Empire; "Occupational Poisoning, etc." which examines the effect upon a small group of workers of the technological inovation of radium watch dials and "Fuel Residuals and Climate" which indicates the possible consequences of our large scale exploitation of carbon-containing fuels.

IV-E-1. Discussion questions and answers for Topic 5

Discussion questions for "Science and Technology and the Cities: A compilation of papers prepared for the tenth meeting of the panel on Science and Technology Committee on Science and Astronautics of the U.S. House of Representatives." For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, $.70. This document contains only the papers which were presented at that panel meeting. A more complete form which contains not only the papers but also the discussions of the various participants and additional reference material is available as "Proceedings before the Committee on Science and Astronautics, U.S. House of Representatives, 91st Congress, 1st Session, Feb. 4, 5, 6, 1969, #1," U.S. Government Printing Office, Washington, 1969.

The interesting thing to note about this series of papers is that although the title is "Science and Technology and the Cities," the real theme of the entire proceedings seems to be that the automobile is destroying the cities and something should be done about it. I regret not knowing a better reading to use for this topic and will be most grateful for any suggestions from readers as to a superior document.

Paper by: John W. Gardner

1. In the middle of the first page he says, "We are now in a position to make the word provincial obsolete." What he implies here in this paragraph is that we now have the technology which makes it pointless to have cities and that we can provide the same advantages to people living in rural communities. Consider your own case, the student at this University. What technologies would make it possible for a student residing in, for example, Kanab, Utah to have the advantages which go with being close to the University of Utah?

2. On page 3 he discusses problems of government in cities. Do these problems exist in Salt Lake City? What is the pay which the people who run Salt Lake City and Salt Lake County receive? How does this compare with the pay for running organizations with similar budgets in industry, or for example, in the University of Utah?

3. As a group, Americans seem to be happy to accept technological change. Some people claim we are down right infatuated with it. On the other hand, we seem extremely reluctant to change government structures at all, and tend to cling to old ones as if they were sacred. Why do we nave these two different views about change?

4. On page 5, near the top, he suggests that as long as we have inflation, we will not be able to provide good low-cost housing for the poor. On the other hand, most economists have shown that inflation and full employment generally go together, so that for the poor it appears that the choice is a job or a house. Is this really the choice?

5. On page 5 he points out that although the housing industry is one of the largest industries in the country, there is no single entity which accounts for more than one-third of one percent of the total market. In contrast, in the automobile industry, we now have four domestic suppliers of which one, General Motors, supplies approximately fifty percent of the market. Why has the market been so concentrated in a field like automobiles, and so fragmented in a field like housing?

6. On page 6, in the middle, he says present tax laws reinforce underlying economic conditions, "...which now inhibit, etc." What kind of tax laws do that? Why do we have that kind of tax law?

7. At the bottom of page 6 he says that factory-built, modular housing units now account for more than one-fourth of all single family housing produced. Where are such houses located in the Salt Lake area? Are they here at all?

Article by: Doxiadis

1. His sixth conclusion on the first page seems to be in direct contradiction to what Paul Erlich says in "The Population Bomb." Who is right, if either?

2. In his introduction, page 10, he talks about man suffering in his cities. In such a statement one ought to make reasonable comparisons. He compares the suffering in the cities to suffering in villages. The other comparison is comparison to other times. Do the men in cities or in the villages suffer more than they did in the past? Do they suffer less?

3. On page 11 he points out that in natural systems, there are growth rates even higher than those of the cities, for example, the physical growth rate of man. Is this a sensible comparison?

4. In the lower left hand corner of page 22, he lists four acts which all people on earth do. Is he right about this? If not, suggest an example of some group of people on earth who do not do all of these things.

5. He defines a city as being the size coverable by a daily urban system. He then says there is no optimum daily urban system. We now have people who commute several hundred miles by airplane to their job, so that one would conclude, for example, that Los Angeles and San Francisco are the same city. Does this make any sense?

6. On page 24 and 25 he discusses the difficulty of doing experiments and the extreme cautions we must take in order to avoid seriously injuring or inconveniencing any, or all, of our populace. If the alternative is to continue with the present system, which seriously injures or inconveniences some or all of our populace, are we justified in going ahead with a new experiment, which may injure or inconvenience some other members? This question was answered by the Chinese communists, who said that they were justified in "sacrificing one generation for the good of future generations." Is that moral? Is it more moral to not intervene and let the present and future generations suffer?

7. On the bottom of page 25, he proposes the only possible way to avoid migration from rural areas to urban areas, in a rather comical way. Is there a way we could accomplish this goal which was not as drastic as his?

8. From the map on page 28, one would come to the conclusion that a very large part of Wyoming was a metropolitan area. For example, there appears to be a very large metropolitan area centered in the Green River area. Does this make sense? Is this a case of the statistics used leading to a nonsense conclusion?

9. In summing up, is your overall impression of Doxiadis, that he is: (a) a brilliant prophet of the future, (b) an articulate man who makes interesting speculations about the future, (c) a routine man who has a flare for words, (d) a crackpot, (e) none of the above, but a _____?

Questions for Spilhaus

1. On page 34 and 35 he says that zoning is the absolute wrong way to control what goes on in our cities. For years the best educated people in our

communities have fought for zoning, and tried to make it more effective. Are they wrong?

2. Do all the members of our society consider a junkyard a "psychological insult?" Or is he proposing a society of, by and for the alphas?

3. Do any cities exist which have the size limitation he proposes on page 36?

4. Is he right about the marvelous things to flow from surface chemistry and physics? Have we already had any progress in building resulting from those advances?

5. On page 40 he proposes cities with "infrastructures containing all the services." Do such cities exist now? Where?

Questions for Llewelyn-Davies

1. Are any such new cities planned or under construction in the U.S.A? If so, how do they resemble, and how do they differ from the British ones?

Questions for Webber and Angel

1. On page 57 they state that the trade-offs are between high-cost rent for close-in locations and transportation costs for outlying locations. What are the other considerations that go into this sort of decision?

2. On page 59 they remark the test of goodness of a transportation system is still a transportation test, that is, that other considerations are not brought into effect. Is this true? Is this true in the planning of the transportation network for Salt Lake City or for this campus?

3. On page 61 they say "the perfect transportation system giving instantaneous, door-to-door, congestation-free service can be supplied only in fairy tales and science fiction." Is this true? Can we conceive of no way in which this could be accomplished? Is this prediction like Simon Newcomb's of the impossibility of manned flight about to be overturned by the facts?

4. On page 62 at the beginning of the next-to-the-last paragraph, they put down what is probably the most eloquent praise of the automobile one can find. Are they right about this? Is this a controversial statement?

5. At the top of page 70 they raise the question of what should be done about groups like the New York taxi drivers who have invested several thousand dollars each in taxi permits. These permits are issued by the city which receives nothing or a nominal amount for them but the supply is limited so that the person who pays very little for it subsequently sells it for a very high profit. Is society obliged to compensate the person who has paid a high price for something which the city gave out at no cost? Are there other examples where some permission or license of the government which was issued at no cost or negligible cost was then allowed to be traded for a price and subsequently became a valuable commodity which the government should perhaps purchase at a high price in order to restore free trade?

6. In this article they propose that by letting the "middle majority" optimize their transportation situation we have greatly disadvantaged other groups.

Cite other examples in which letting one group in society optimize its position results in serious disadvantage to other groups in society.

Questions for Seifert

1. On the bottom of page 78 he says that new basis of appraising are needed and "the project may be better justified by the expected social return than by its economic return." What components should be considered in deciding the social return?

2. On page 80 he discusses at length the "automatic guideway." How much should America be willing to pay to develop such a system? Should we be willing to pay as much as we paid for exploration of the moon?

3. On page 81 he gives a very negative forecast of the prospects of battery operated automobiles. Is this Simon Newcomb and the airplane all over again or have we a better basis for making this statement?

4. Suppose we could develop automobiles based on lead-acid storage batteries of the type used to start current automobiles and suppose we required over a five-year period all the automobiles in the country to be of the lead-acid storage battery type. What changes would this cause in the American industrial set-up?

5. At the bottom of page 81 he says that rapid transit systems cannot meet systems costs. If they cannot meet the cost, on what basis can they be justified?

6. On page 83 he discusses a rapid train which was to be in service between New York and Washington this year. What has been the fate of this? Have newspapers indicated that this is a financial success or not?

7. On page 84 he discusses the problem of having the FAA as the operating agency also be responsible for developing the new system and suggests that this is basically the wrong way to do it. Are there examples in which a firm or agency was operating current technology and simultaneously rapidly pushed entirely new technology? Are there examples in which in this situation, those operating the current technology held back new technology?

8. On page 85 he suggests that some new ideas in airport financing were called for and that a head tax will be levied on air travellers, etc. Who pays for airports now?

9. Spilhaus, in the earlier article, suggests that one ought to consider the whole of society as an engineering system. Seifert seems to say that we ought to consider the whole of transportation as an engineering system. Are these views contradictory? Which of these views is right, if either?

Questions for Perloff

1. What is this article doing in a book called "Science and Technology in the Cities?"

2. From what he says does it appear that he favors the "technological quick fix" or does he favor "social engineering?"

In this course we didn't discuss page 95 and what follows of this book. These make interesting reading and are suggested for pleasure and interest, but were not included because of excessive length.

My answers for "Science and Technology in the Cities."

Answers for John Gardner

1. I don't believe we could do it. One could bring the classes by TV, etc., but the intellectual stimulation, which goes with contact with others, would probably not be transferable. The social life would not be transferable.

2. They certainly do. I believe the pay is about $12,000 to $15,000 per year. This compares very poorly with that of people running comparable size industrial organizations or universities.

3. One reasonable answer is that the government is a bridge to the past and that people look upon it that way, very unfortunately. Another is that the technological changes we accept privately, whereas to change the government we must act in concert, which is harder. Finally, there are large interest groups who stand to benefit financially from the new technology and very few who can defend the old technology by appeals to emotion against it. On the other hand, with governmental change there are large groups which stand to lose financially and are prepared to use all sorts of emotional arguments to talk us out of it.

4. I am afraid the answer is yes, unless we are prepared to make some real changes in our governmental system and accept governmental paternalism over all the poor.

5. This is answered in detail by Burnham Kelly, "The Prefabrication of Houses," MIT Press and John Wiley, 1952, 45-55. See also Peter Blake, "God's Own Junkyard," Holt Reinhard & Winston, 1964, 23-30.

6. He is talking about property taxes, which basically inhibit fixing up slum dwellings. He is certainly right about that. The history of this is long and involved. Most economists know our property tax laws are absurd; no one acts on this knowledge.

7. Here he is talking about mobile homes. In mobile homes, one can avoid all sorts of the legal restrictions, zoning codes and the like, which prevents you from using modern, prefabricated systems. The net affect is that we put fake wheels on these prefabricated houses, in order to make them pretend they are something else, a very sad comment. The vast majority of Mobile Homes <u>never</u> leave the county in which they were sold.

Answers for Doxiadis

1. It is a direct contradiction and I think Doxiadis is wrong.

2. I think they suffer less; C. P. Snow has similar comments in his, "The Two Cultures" (which is used in Topic 6).

3. I think this is a ridiculous comparison. Man lives a short time and is replaced, cities live a long time and are not replaced; man's growth curve is

of an entirely different type than those of a city. Man's curve is exponential going against a constant; the city is probably an exponential.

4. I think not. Most pre-industrial societies do not do these things at all, classic examples are the Eskimos, the New Guinea natives, many people in South America.

5. When the airplace came along, this got to be ridiculous. I don't think it makes any sense. However, in earlier times it really did and I think that we have a basic truth here, which has gotten out of hand.

6. This is a moral question, which nobody has any happy way out of. I think his anti-experimental position is extremely cautious and hard to defend. At this point, it makes sense to discuss the next thing he says, which is not telling people you're doing experiments on them. This is certainly not for the people's benefit; witness the famous case of the lighting experiments at Western Electric, where merely telling the people that you were going to do an experiment on them made them perform better. On the other hand, it ruined the experiment.

7. Put good job opportunities in the small towns.

8. I think this is a case of the statistics leading to a nonsense conclusion.

9. Doxiadis comes out somewhere between common sense and Marshall McLuhan. I think he has more reasonable suggestions than McLuhan, but he certainly has some wild ones.

Answers for Spilhaus

1. They are both right. What Spilhaus says is that if we were rational we would set up an entirely different system. I agree with that. The present advocates of zoning are fighting the irrationalities of the current system, probably the wrong way.

2. I suspect that this is the case of an alpha, wanting to impose alpha values on everybody.

3. Historically, some cities have done this, witness Mt. Saint Michele, the Italian hill towns, Dutch cities and the like. I know of no American cities which have done it, except perhaps San Francisco, which has been forced to do it against their own cupidity by the geography of the situation.

4. No, that is a bunch of nonsense. The first class surface chemistry and physics in the world has largely been devoted to such problems as paints, coatings and finishes. I don't believe that there is any really large body of unexploited scientific knowledge in this area. This is just a case of somebody tooting his own horn.

5. He is talking about a horizontal apartment building. Vertical apartment buildings have this already.

Answers for Llewelin-Davis

1. There are several examples: Reston, Virginia, Columbia, Maryland and some in and around California. These are all run on a for-profit basis and some have found real troubles getting the patient capital that he describes. None of them have condemnation rights, which some of them would have benefited a great deal from. In the case of Reston, the transportation to and from has been very, very poor, with dismal results.

Answers for Webber and Angel

1. Convenience of access is frequently much greater in the outlying locations. This has been one of the main problems with downtown locations; traffic there is so jammed and parking there so difficult that it is much easier for employees and customers to get to outlying locations. Other major considerations are the noise, dirt, and crime problems in downtown locations which seem to be a great deal less in remote locations.

2. I believe this is true. It certainly seems to be true in what we have seen in the recent past in this city and in this University.

3. I think it is probably true. I can conceive of no way to accomplish it, which perhaps indicates a failure of imagination on my part. However, I have heard of no proposal for accomplishing it, so that my failure of imagination is shared by others. I would be delighted if it were overturned like Simon Newcomb's, but I do not expect it in the near future.

4. I believe he is right about this and I do not believe it as a controversial statement. The net effect of the automobile has been greatly increased freedom. There have been ill effects which we are now beginning to notice and which one hopes we will be enlightened enough to eliminate without negating the net benefit of the automobile.

5. I can cite three examples: (a) Liquor licenses in California. When a new liquor license is to be issued many applicants apply for it. The requirement to apply is that one operate a restaurant or eating place in the general area where the new license is to be issued. From the applicants, the licensee is selected by lot. He pays a nominal sum to the State. After he has held the license and operated a bar in his establishment for a short period of time (I believe two years) he can then sell this license at a very high price to the highest bidder. (b) Similarly, in the Western United States, grazing rights on federally owned land were allocated for no down payment and a modest annual rental to various sheep and cattle grazers. The rental is now relatively small compared to the true value and the rights which seem to continue indefinitely are sold at very high prices from one grazing user to another. (c) The third example is television licenses. These are issued by the FCC, originally at a very low price and now sell for millions of dollars.

6. For many years the railroads in the United States had sufficient political power that they could indeed adopt a "public be damned" attitude, and they optimized their position at the expense of all their customers. Currently they are optimizing their position by getting out of the passenger business; this certainly works a hardship on some of their potential customers. The garbage collection agencies in the United States normally set up rules for garbage preparation by their customers which largely insure the convenience of the garbage collectors rather than the convenience of the customers. As

far as I know, all city and county governments set up their rules and procedures in a way to make it most convenient for the city or county government to operate rather than for the customer. For example, in Salt Lake City it is virtually impossible to transact any business with the county and city government by phone or mail. One must appear in person. The operational convenience of the school systems requires that all children attend schools in their immediate neighborhoods. This results in racial segregation of some schools. Numerous similar examples can be cited.

Answers for Siefert

1. Unemployment caused by the new transportation system, new employment opportunities for other groups caused by the transportation system, pollution reduction or increase due to it, increases or decreases in land values and tax revenue due to it, asthetics.

2. Many people are enthusiastic about this project; I am not particularly. I do not think we should pay as much for it as we paid for exploration of the moon.

3. We certainly understand the problems with battery-operated automobiles much better than Simon Newcomb understood the problems with the airplane. Unless there are new types of batteries as yet completely undreamed of and much higher in energy density, there seems little hope for the battery-driven automobile.

4. The lead mining, smelting, and manufacturing industries would be required to enormously increase their output. Simultaneously the giant apparatus for the production and distribution of gasoline would be shut down. The electrical production and distribution facilities of the country would have to be enormously augmented. The entire manufacturing facilities of the auto companies would have to be revamped. Most of the automobile service people would have to be entirely retrained. Furthermore, the lead or acid storage battery automobile could be expected to have a much lower maintenance requirement. Hence, the number of people involved in auto maintenance would greatly decrease.

5. On the basis that the social return is sufficient to make up for the system. operating losses. In many cases this seems to be certainly so. As they point out in a city with no municipal transport a large number of people are effectively immobilized. Furthermore, to the extent that people can be encouraged to use municipal transport instead of their own private cars our investment in roads, etc., is correspondingly reduced and the existing road systems can be made to work which they could not if there were no alternative system.

6. Apparently this has been a financial success and operates fairly well. Most competent observers feel that the railroads could do much better if they really tried. The Japanese do much better.

7. The telephone system has consistently tried to develop new technologies while operating the old ones. However, they have simultaneously required that all new technologies be compatible with the existing ones. There may have been a time at which it was truly better to junk the whole existing system and put in a new one; the telephone company would never do this.

The railroads have certainly taken the viewpoint that new technology is unwelcome. The airlines more or less reluctantly accepted the new technology of jet aircraft; once the extremely low operating costs of these aircraft were shown they then jumped on to it wholeheartedly. Military history is full of examples of the admirals and the generals having a stake in the existing technology and trying to prevent the development of the new technology.

8. In the recent past airports have largely been built by cities and paid for by charges which the cities make against the airlines. Some of these have run at a profit; most at approximate break even. In 1970 President Nixon has announced a new tax on air travelers to pay for airport expansion; this indicates that Siefert was either prophetic or knew what was coming.

9. Yes they are contradictory. One would hope that ultimately Spilhaus' viewpoint wins; however, for the near term it is better to take Siefert's viewpoint than the one on which the country is currently operating.

Answers for Perloff

1. Clearly this is a paper about social changes rather than technology or science.

2. It seems clear that he favors "social engineering."

Discussion questions for S. C. Gilfillan, "Lead Poisoning & the Fall of Rome," Journal of Occupational Medicine 7 (1965), 53-60.

Gilfillan presents data to support the hypothesis that because the upper classes in Rome used lead cookware, their birth rate was severely reduced. Over several generations this led to selective breeding, which removed ability and talent from the population. To this he attributes the decline of the Roman genius for organization and hence, the ultimate destruction of Rome.

1. On page 54 he says that lead is now banned from interior paint. How long has it been banned? Are there buildings still standing which have lead interior paints?

2. If his argument is correct that lead was a "class poison," why didn't the Romans see that? Shouldn't there have been enough evidence available then?

3. If he is right, then this is the perfect case of a simple technological change destroying a great society. How should the Romans have protected themselves against such a disaster? How should 20th century Americans?

My answers for "Lead Poisoning and the Fall of Rome."

1. It has been banned from interior paints, probably since the 1920's. There are buildings standing which have a great deal of lead paint in them, mostly in the slums. There is a two-page article on this subject, in "The Sciences," a journal of the New York Academy of Sciences, Vol. 9, #10 (Oct. 1969), 12-13. It points out that ghetto children quite regularly have significant lead poisoning problems because of the old buildings they live in.

2. Apparently the Romans did see that there was a class problem because of their laws requiring people of the upper classes to marry or adopt people from the lower classes. The fact that it had a technical basis wasn't apparent to them because they were not oriented to considering technological reasons or scientific reasons for things that occurred around them. Thus, with their orientation as to reality, it probably never occurred to them why this was happening.

3. The Romans probably could not protect themselves against such a disaster because they did not have the scientific background to do so. 20th century America should do so by carefully considering the consequences of technological changes. Something we are not doing as well as we should is considering these consequences.

Discussion questions for Harrison S. Martland, "Occupational Poisoning in Manufacture of Luminous Watch Dials," Journal of American Medical Association 92 (Feb. 9, 1929), 466-473. This is a report on the radium poisonings caused by the introduction of luminous watch dials.

1. What similarities exist between this case and "Lead poisoning....?" What are the significant differences?

2. Why did Dr. Flynn take so long to reach the correct conclusion?

3. Who is responsible for preventing such things now?

My answers for "Occupational Poisoning..."

1. The significant similarity is that in those cases a technology was introduced before the real hazards involved were known and understood. The significant differences are that we had a scientific structure which allowed us to perceive this while there were only a few injured people instead of a great number.

2. Probably because he was working for the companies which stood to benefit from the conclusion not being reached.

3. No one is really responsible for such things now. New technologies are introduced all the time. Only after the hazards are realized do we begin to set up institutions to combat them.

Discussion questions for Hans E. Suess, "Fuel Residuals and Climate," Bulletin of the Atomic Scientists 17 (May 1961). This is a popular account of the "CO_2 Greenhouse Effect."

1. Is this science fiction or is this really something to worry about?

2. If, as he says, the oceans contain 60 times more carbon dioxide than the atmospnere, will atmospheric measurements tell us quickly what is happening?

3. If the world was slowly warming up, what measurements would let us know this?

4. If the world did increase significantly in overall temperature, what sort of troubles would this cause us?

5. Suppose we found ourselves in the position that the world was indeed warming slowly and that we had put enough carbon dioxide into the atmosphere and the ocean that we could not expect this warming trend to stop for many centuries, could we find a technological fix to avoid the disaster that this protends?

My answers for "Fuel Residuals and Climate."

1. Apparently this is something to really worry about, although we don't know for sure yet. I have been unable, so far, to find any really detailed material on this topic. The one I show here is not particularly detailed and does not give suitable references.

2. No, they will not; that's the problem.

3. Perhaps measurements on glaciers; over the last sixty years, glaciers have been shrinking. In the last few they have begun to grow. There seem to be more effects here than simply that that's due to CO_2.

4. The worst part would be the rise in the levels of the oceans, flooding a large part of the agricultural land of the world.

5. Probably. If we were to run the inverse of the scheme the Russians proposed for making the Arctic Sea an open sea, that might affect it. Another thing we could do is go to the truly cold places in the world where there is negligible precipitation, like Antarctica and Greenland and spray or pond sea water on top of the existing icecaps. We could presumably, if we were willing to spend enough money, thereby make the net amount of ice melting be negligible.

IV-E-2. Additional material for Topic 5

One possible alternative is Harold Gilliam, "The Fallacy of Single-Purpose Planning," Daedalus (Journal of the American Academy of Arts and Sciences) 96, #461132-1157. In this article Mr. Gilliam talks about the misuse of land which results from letting each agency or land user decide by himself how the land should be used. The examples he cites are all from the San Francisco Bay area; the proposed Bodega Head nuclear power plant, the proposed concrete channel for the Napa River through the City of Napa, the use of Golden Gate Park as a freeway site, the filling of the San Francisco Bay for commercial development. In all of these cases he points out that the individual u[illegible] this case, the Power Company or the Army Corps of Engineers or the Highway Department or the individual communities bordering the Bay) acted only to satisfy the need of their particular agency and did not consider the whole picture. This article is very largely directed to the question of land use. I consider it an interesting problem but not necessarily germane to the overall purposes of this course. For this reason I consider it an alternative and not a regularly used reading in the course.

Another possible choice is Garrett Hardin, "To Trouble a Star; The Cost of Intervention in Nature," Bulletin of the Atomic Scientists 26 (Jan. 1970) 17-20. This article by Professor Hardin considers the kind of problem I am interested in here, but on a bit more of an ecological (in the naturalist's

sense) viewpoint than I would prefer. He does, however, consider examples of the Aswan Dam and the SST, both of which I consider good examples. I plan to use this as text material in a future version of the course to see how the students like it.

Another topic which I tried at one time in this course is the problem of how we have become interrelated and tied together by our increasingly complex technological setup. The classic example of this is the power blackout in the northeast in November, 1965. In this case a small malfunction in a single piece of equipment resulted in enormously complicated effects in a large area. I regret to say that I have been unable to find a document which has been really successful with students in reading about this and in thinking about the problem of the extent to which we have become interwoven with our machines. In the event I try this again (which I may) the document I will use (which I have not tried on a class) is Gordon D. Friedlander, "The Northeast Power Failure--A Blanket of Darkness," IEEE Spectrum 3, February, 1969, pp. 54-73. See also same journal, May, 1966, pp. 84-90, which contains comments on the foregoing article. The other articles which I have used (before I found the one by Friedlander) and which might be considered, but which I do not consider as good as Friedlander's article are, "Blackout: What Did They Think?" Electrical World 163, February 7, 1966, pp. 153-156 and Leonard N. Olmstead, W. D. Brown and Julius Bleiweis, "The Blackout: It Happened in Twelve Minutes," Electrical World 163, January 23, 1966, pp. 67-74. The latter two were tried on an Honors class with a handout sheet giving definitions of the terms used. They were moderately successful.

Another possible choice is M. R. Bloch, "The Social Influence of Salt," Scientific American 209, July, 1963, pp. 89-98. This document presents the view that previous historians have overlooked the great significance of salt supply in the development of civilization. It fits in here as an indication that we have not considered one of the technological inputs into our culture as adequately as we should. The article makes some very strong claims as to the importance of salt which I have not had a chance to document or see possible refutations of. My principal reason for not using it regularly is the difficulty of obtaining reprint rights from Scientific American.

Another subtopic which could be introduced here is the manner of the "input-output analysis" of the economy which treats the same sort of thing from an economist's viewpoint. Unfortunately, I do not know of a suitable reading which could be introduced here. The best I know is Wassily W. Leontief, "The Structure of the U.S. Economy," Scientific American 212, April, 1965, pp. 24-35. I tried this on an Honors class and they agreed with me that it is too much talking about what sort of a tool this is and not nearly enough about what one has learned from the use of this tool. Also, there is the problem of obtaining reprint rights from Scientific American.

Another possible choice is Richard L. Meier, "The Social Impact of a Nuplex," Bulletin of the Atomic Scientists 25, March, 1969, pp. 16-21. A "nuplex" as discussed in Weinburg's article in Topic 4 is a proposed combination of a large nuclear power plant--desalting--industrial complex which would be erected at some arid location adjacent to the ocean. In this article, Meier discusses some of the problems which would result from attempting to develop such a thing. There is enough reading about on nuplexes that one could take this up with a class if he saw fit to do so.

Finally we might use P. M. Borisov, "Can We Control the Arctic Climate?" Bulletin of the Atomic Scientists 25 (March 1969), 43-48. In this article Borisov proposes a dam across the Bering Strait with a large pumping plant which would make the Arctic Ocean ice-free and thus radically alter the climate in the northern half of world. As far as I can tell this is not science fiction. I tried this reading on an Honors class. They were aghast to realize that it is well within the capabilities of men to make such vast changes in our planet. This raised all sorts of interesting questions as to how we should control this power.

IV-E-3. Examination questions for Topic 5

1. In the year X medical research indicates that the smog from auto exhaust gases is much, much more dangerous to human life than previously believed. Therefore, in a national referendum it is decided that in the year (X+2) and all succeeding years, all new cars must be steam engine types (which produce far fewer pollutants). Indicate the effects of this change on our social, industrial and governmental setup.

2. In the Spilhaus paper in "Science and Technology and the Cities," are mentioned several ways to better plan and control the development of our cities. Summarize the best points given by Spilhaus.

IV-E-4. Paper subjects for Topic 5

1. Farm mechanization drives illiterate farm workers off the land, into the urban ghettos, where they go on relief. Is there a relation between the cash savings of the farm employers who dispense with expensive workers by using cheap machinery, and the amount we pay out in welfare? Would the total cost to all of society have been less if we had banned the mechanization of farming, and kept those people on the land?

2. Elimination of environmental difficulties is frequently associated with conflict of huge financial interests. Pollution due to hydrocarbon fuels could be minimized by shifting to nuclear reactors. Discuss the problems which would be encountered if we decided--by law--to make this shift. What steps could be taken to minimize the transition? You use a different example than fossil fuel vs. nuclear energy.

3. Analyze the technological problems in urban renewal.

IV-F. Topic 6. Science and Government

This topic is the last of six in the course as currently offerred at the University of Utah. The two following topics are additional ones which maybe fit in, but this one probably would be taught last in any event. The basic questions here are, "What should the Government's science and technology policy be? Who should the Government's science and technology advisors be? How should the policies be set?" A subsidiary question is how should our technological resources be allocated?

The principle readings for this course are two books by C. P. Snow, "The Two Cultures" and "Science and Government." These are both short and available in inexpensive paperbacks. "The Two Cultures" is a famous document in which Snow raises a set of questions which were apparently not widely articulated before and which he is given credit for originating. (He himself points out in the appendix to this work that many others have had similar ideas and that his formulation of the problem was merely the one which attracted the most attention.) In any event it is a widely quoted document which although controversial is certainly worth reading. The second book, "Science and Government" cites one example where Snow feels that the process of obtaining scientific and technical information for the leaders of Government went wrong with disastrous consequences.

The other readings in this section are "Bechtel's Pipe Dream" which indicates a case where a technologically feasible and sound program was defeated for political reasons, "The Rise and Fall of Lysenko" which cites the most famous recent case of governmental intervention in science and then three readings on the Astin-Weeks controversy may have some parallels to the Lysenko case. Next we have "Four Lane Menace to California's Redwoods" which deals with the often heard comment that "the highway builders are bulldozing the world." Then finally, "Hot Engineering Triumph" which discusses the technological masterpiece of the hot shave cream.

IV-F-1. Discussion questions and answers for Topic 6.

Discussion questions for C. P. Snow, "The Two Cultures: and a Second Look," Mentor, 1963.

C. P. Snow points out what he sees as a tragic gulf between the scientific and non-scientific parts of the intellectual community. He claims that political power in our societies is in the hands of the non-scientists and that the scientists must save us from future disasters. His basic proposal is that the non-scientists must adopt a higher standard of scientific literacy.

1. Do you agree with his statement on page 12, that Rutherford is indeed the Shakespeare of science?

2. Do you agree with his statement on the bottom of page 16, that the scientists "have the future in their bones?"

3. Do you agree with his statement on page 20, that "the scientific edifice of the physical world is the most beautiful and wonderful collective work of the mind of man?"

4. On page 30 he says, "industrialization is the only hope of the poor." Is that true? Has no agrarian society ever been happy? If it is true, should underdeveloped nations devote all of their energies toward trying to industrialize, as many are now doing?

5. On page 38 he suggests that what is needed is to educate all of our populace in some fundamental and rigorous science and mathematics. Since the first launching of Sputnik in 1957, there has been some effort in this direction in the high schools in this country. Has this been successful?

6. At the bottom of page 47 he gives a rather dismal analysis for the decline of the quality of postal services, railway services and the like. Is he right about this analysis?

7. On page 54 he comments that "original ideas don't carry at that speed." Can anyone cite a truly original idea, which was accepted that rapidly?

8. On page 73, in the middle, he makes as strong a sales pitch for going over to the technological society, as one can make. Many current critics simply refute this by saying that the machines are enslaving us all. Who is right about this?

9. On page 76 he makes the quote from Plumb, which would lead one to believe that romantic attachment to the past is foolish. Does it follow logically from this, that if we could choose to be born at some future age rather than now, we should?

My answers for "The Two Cultures: and a Second Look."

1. No, I don't agree. I think that in the discussion here one should point out the cumulative nature of science as opposed to the non-cumulative nature of arts. We perform Shakespeare's plays today because no one knows any better way to write plays. We do not repeat Newton's experiments because we know far better ones.

2. I think this is an example of his prejudice toward the scientific viewpoint.

3. An alternate suggestion might be, language and all its ramifications.

4. In the past, agrarian societies have been happy. The question is whether they can be happy side by side with much richer, industrial societies. If they scrupulously control their population growth, could they not develop so that their annual income was as high on the average as those in an industrial society? I think the answer is yes.

5. The efforts in this direction have largely resulted in making high school physics and chemistry so difficult that we have driven the liberal arts students out of them. This is obviously the wrong way to go. See C. E. Ronnenberg, C & EN (June 1, 1970), 50.

6. I think so.

7. I know of no good example.

8. That is really what this whole course is about.

9. There the dilemma is the question of whether we will succeed in overcoming the threats to the entire life on this planet. If we have a nuclear war, then choosing to be born at a future age might be choosing not to be born at all. Similarly, if we manage to pollute our planet to the point where life becomes intolerable, then also, one might not choose to be born at all. The conclusion here is that, if we avoid those things, I think the logical person would choose to be born in the future age, but perhaps we won't.

I asked the students whether this book was directed at members of one culture or the other, or both. Most of them didn't know. They are not very perceptive on such matters. After some prodding they recognized that this was directed very pointedly at one of the "cultures."

I strongly recommend that anyone teaching about this book read the reference cited on the bottom of page 56 (F. R. Leavis', "Two Cultures? The Significance of C. P. Snow," available in pocketbook from Pantheon). This response by Leavis is a biting personal diatribe against Snow in which he attempts to refute all of Snow's arguments by asserting that Snow is an incompetent nobody. One must read it to believe it.

Leavis is probably the critic of English most responsible for popularizing the writings of D. H. Lawrence among English scholars. There seems an obvious connection between this and the quotations from D. H. Lawrence which appear in Snow's, "A Second Look."

After reading both Snow's, "The Two Cultures" and Leavis' response I inquired of a colleague in the English Department which, if either of them, is taken as a serious English scholar. My colleague replies that Snow's novels are considered worthwhile contributions in their particular type of novel. Similarly Leavis is considered a significant English critic although somewhat extreme in his views. Thus neither can be dismissed out of hand as being a nut or an incompetent.

Discussion questions for C. P. Snow, "Science and Government," Mentor, 1960.

Snow recounts the story of the conflicts between Tizard and Lindemann, from which he draws some lessons about how science ought to be managed in democratic governments.

1. On page 11, does he state the questions correctly? Is it impossible to teach the politicians to understand the general technological difficulties? Should we replace them with scientists?

2. At the end of page 38 he poses the difficult dilemma, that if those who knew the right political course to follow had succeeded, they might ultimately have defeated their goals. Are there any other examples in history where a group has thought they were working to accomplish one policy and ended up accomplishing the opposite?

3. On page 44 he cites the fact that the same basic kinds of weapons were developed in all of the countries in the Second World War. This raises the interesting question, "Dare a country not pursue a possible technological route, which its competitors might pursue?"

4. On page 53 he points out that because of the basic ignorance of most political leaders in science and technology, they are largely swayed by the salesmanship of the various competing camps. Is this a hopeless dilemma, or can we find some way that they may have objective evaluations instead of policy being ultimately decided by which side has the best salesman?

5. On page 62 he indicates that Lindemann was a "gadget man." What is the opposite of a gadget man?

6. On page 65 he practically comes to the point of saying we should abolish secrecy. Do you agree? Should we abolish all secrecy in government?

7. From what he says at the end of page 74, whom do you conclude has "the gift of foresight?" Do you agree with his conclsuion as to who has the gift of foresight?

My answers for "Science and Government."

1. I think he does. The alternatives are indeed to elect politicians who can understand scientific and technological questions or to have them ultimately make their choices based on the advice of whichever scientist they believe. One should comment here, that the case he cites is particularly difficult because it was a war-time situation, in which open debate was not possible. In our present society, open debate is possible and the sort of thing he mentions does not really come up.

2. This isn't really a technology question, but rather a political one. Certainly the election of Lyndon Johnson in 1964 was interpreted by most Americans to mean that America would not get involved in a land war in Asia. Similarly, the election of De Gaulle by the French was interpreted by most Frenchmen to mean that the French would maintain their position in Algeria. The Czech students who in January of 1968 put pressure on Dubcek to speed his liberalization program and not to compromise with the Russians, clearly ended up accomplishing a result different than what they had in mind.

3. The answer seems clear that if a weapon can be developed, a powerful nation can scarcely avoid developing it. One sidelight here worth discussing is the common story which always reappears in these classes about the oil companies suppressing the carburetor that will greatly increase the gas mileage or the battery companies suppressing the everlasting battery, etc. These are all nonsense and numerous examples can be cited of the multiple invention of any such thing, for example, the Hall Process for aluminum, which was simultaneously invented in France.

4. Salesmanship is important, but the system we now use in this country of choosing science advisors, largely on the basis of their being acceptable both to the political leaders and to the scientific community, seems to be as good a scheme as is available. This certainly would have solved the Lindemann problem, if it could have been used in England.

5. The opposite would probably be a "systems" man. Tizard was certainly a systems man.

6. Probably.

7. He is really suggesting that scientists have the gift of foresight. That is a very debatable point.

In this book Snow gives a glowing account of the character and virtues of Tizard and a rather negative account of the character and virtues of Lindemann. Naturally Lindemann's friends and colleagues have responded indicating that Snow has his history all wrong and that Lindemann was really right more often than Tizard. For a fairly detailed rebuttal of Snow's writings here see the Earl of Birkenhead, "The Prof in Two Worlds; The Official Life of Professor F. A. Lindemann, Viscount Cherwell," Collins, St. James Place, London, 1961. A simple quote from this book will indicate its tone, "Sir Charles Snow's account of the dispute between the two men resembles a victorian melodrama, in which virtue in the form of Tizard is triumphant and the villain Lindemann hissed off the stage. In his assessment of Lindemann's character he was no doubt assisted by his imaginative powers as a writer of fiction, and his conclusions are so ignorant and misleading to anyone who knew the dead victim as to approach caricature."

As a sidelight on the development of radar and its military consequences, those readers interested in military history would certainly enjoy Gordon D. Friedlander, "World War Radar: The Yellow-Green Eye," IEEE Spectrum 3 (May 1966), 62-71. In this short article Friedlander accounts how the differing qualities of radar settled the European naval battles of the Second World War. Although the example which Snow cites of the effect of radar and the Battle of Britain may have been the most decisive, this other example is very interesting.

Discussion questions for "Bechtel's Pipe Dream," Fortune 46 (Nov. 1952), 103-4.

Bechtel showed that natural gas which was being thrown away in the Middle East could be pipelined to Western Europe and sold there at an immense profit. His plan never came to fruition because of the political difficulties in doing what was technologically logical.

1. Is what Bechtel proposed technologically feasible?

2. Is what he proposed economically feasible?

3. Is it politically feasible?

4. Faced with the political problem seen here, what route has been followed? Have the countries agreed on the international cooperation necessary to make this practical, or have they found other ways, which make it unnecessary to have such cooperation?

5. Are there other examples where the existence of political boundaries prevents us from doing things the right way technologically, and instead, forces us to do something which is technologically and economically inferior?

My answers for "Bechtel's Pipe Dream."

1. Yes.

2. Yes.

3. No. The political problem which stopped this, mostly, was the unreliability of any contract one might sign with Yugoslavia. There seemed to be no way to build the pipeline without that. Similarly, a pipeline has a long payout period so many long term contracts would be needed; these would have been speculative.

4. Natural gas has been thrown away, and they have used oil as a principal energy source. Also, recently we have gone over to using liquified natural gas as a solution to this problem. The liquified natural gas business only requires the agreement of two countries. So far, the countries like Algeria have not seen fit to try to raise the price because they would be priced out of the market. We will see how Libya does now that they have a new nationalist government.

5. Yes, there are numerous of them. Examples: All the business about the U.S. oil import quota, where for example, we at Brownsville, Texas truck

the oil across the border and then bring it back to evade the quota rules. The problems with building the right kind of low-level canal in Columbia, because they don't want to do it. The difficulties we had in agreeing on control of the waters in the northwest, which flow across international boundaries and so on ad infinitum, ad nauseam.

Discussion questions for E. W. Caspari and R. E. Marshak, "The Rise and Fall of Lysenko," Science 149 (July 16, 1965), 275-278.

Lysenko's rise to power with Stalin, career of power, and fall from power under the current Soviet rulers is chronicled here.

1. Are there any similarities between the story of Lysenko's rise to power and that of Lindemann? Are there any significant differences?

2. In the case of Lysenko, there were technological implications, i.e., how the Soviet Union should run their farms and scientific implications, i.e., what theories of genetics were correct. Were there similarly scientific and technological considerations in the conflict between Tizard and Lindemann?

3. According to this article, the Soviet Union has decided to abandon Lysenkoist genetics and go over to the same kind of genetics as taught in the west. Did they do this primarily for technological reasons, or did they do this primarily for scientific reasons?

4. Cite an example, if possible, of a case in which a western country, in recent years, has let its ideological viewpoint or philosophical viewpoint determine what sort of science would be accepted and what sort would not be accepted?

My Answers for "The Rise and Fall of Lysenko."

1. Yes, in that the person coming to power was in a position to dogmatically override the opinions of others on technical matters. Also, both cases occurred at a time when free debate and discussion was forbidden. Normally this is not the case in England, but in wartime it was. One of the significant differences was that Lindemann did not propose any theoretical consequences of what he was doing and presumably did not upset English theoretical science, but only the application of science that was already known.

2. Apparently there were no scientific controversies between Lindemann and Tizard, but only questions of priorities and applications.

3. Apparently they did it mostly for technological reasons, mainly that Lysenkoist genetics clearly is impractical for solving farm problems. There was probably, however, a scientific component to this, namely that they realized that they were being laughed at throughout the world for ignoring modern science in the field of biology.

4. The Astin-Weeks case, next reading, is a case of this to some extent. Weeks' actions were guided by his political beliefs rather than by any scientific understanding. Similarly, Germany under Hitler expelled Einstein, and as far as I know, suppressed his ideas.

Discussion questions for "The Astin Weeks Case," Anon "National Bureau of Standards; Astin Weeks Case," Bulletin of the Atomic Scientists 9 (May 1953), 103-4 and 146; also Graham DuShane, "Test by Testimonial," Science 123 (June 15, 1956) and Graham DuShane, "Tear's Gold in Them Bills," Science 128 (Dec. 26, 1958).

The National Bureau of Standards was forced into the position of testing a battery additive which it reported to be valueless. The manufacturer of the battery additive contested this result so vigorously that the Secretary of Commerce ultimately fired the head of the National Bureau of Standards. The subsequent reaction from the scientific community led to the reinstatement of the head of the National Bureau of Standards.

1. Should the government be in the business of consumer testing of products at all? If so, under what circumstances?

2. How much sense does it make for the Secretary of Commerce and twenty-four Senators, to intervene in a scientific testing laboratory to express their desire that the outcome of objective tests be in one direction or another?

3. At the top of the middle column on page 104 we have a quote from President Eisenhower saying that Secretary Weeks would be the last person to be arbitrary or unjust in such circumstances. Was his faith in Weeks justified?

4. On page 146, in the lower left, Mr. Weeks' statement gives considerable credit to the scientific competence and integrity of Dr. Astin. Is this statement reconcilable with his previous statement?

5. As a general proposition, should the Secretary of Commerce be entitled to hire and fire heads of National Bureau of Standards, or should the National Bureau of Standards be above such political intervention? If your answer to the last question is yes, then how should its head be chosen?

6. In the editorial from Science, entitled, "Test by Testimonial," we have Weeks' quote, "but as a practical man I think the National Bureau of Standards has not been sufficiently objective, because they discount entirely the play of the marketplace." Is this what one would consider scientific objectivity, or business objectivity, or are both the same?

7. Just below that, he indicates that, "as a practical man, I do not see why a product should be denied an opportunity in the marketplace." Do you agree with this completely or only for some products? For example, for battery additives, drugs, foods, airplanes?

8. In the next to the last paragraph of this piece, the FTC Commissioner indicates that although the scientific testimony is on one side of the controversy, the consumer testimony, i.e., testimonials by satisfied users, should be given greater preference. Is that the basic policy we ought to follow? On what kinds of products should testimonials be the basis for acceptance or right of use? Drugs? Foods? Automobiles? Airplanes? Everything?

9. On the second Science editorial, it notes that in August of 1953 Secretary Weeks backed down and reinstated Astin as head of the Bureau of Standards.

Weeks was out of office several years later; Astin retired in 1968. This would lead one to believe that the scientific community had a great deal more political muscle than Secretary Weeks. Is that the way it should have come out?

My answers for "The Astin Weeks Case."

1. This is a highly debatable question. The Government is in the consumer-testing business only for products which it buys for its own use. That was one of the ways this trouble started, when a consumer test basically for the Government's own use was used to discuss a publicly-offered product. Whether it should be or not is a question of value judgment.

2. None whatever.

3. No.

4. No.

5. Ultimately I think that in our society we must rest the authority with the elected representatives, which in this case means the President and his Cabinet, and thus the Secretary of Commerce should be enabled to hire and fire the head of the National Bureau of Standards. What is required is to get higher quality people into Cabinet posts than Secretary Weeks.

6. What he is saying is caveat emptor, which is scarcely a rule of science.

7. Here the question gets difficult. For battery additives, I am inclined to let them be tried, because all that is involved is stealing money from the ignorant. On the other hand, with drugs, what is involved may be sacrificing the life of the ignorant, and with airplanes, sacrificing the lives of all sorts of people. We have some fine lines to draw here. We have in general said that where it is merely stealing money, that's all right, but where lives and health are endangered, then it is not all right to let things be tried by the marketplace.

8. Testimonials should only be allowed as evidence in cases where no sort of objective testing is possible. That, in my opinion, excludes such things as drugs, food, automobiles, airplanes, and almost anything else which has a demonstrable function to perform. On the other hand, things like perfumes, cosmetics, beer flavors, and the like, should be done by testimonial.

9. I think so.

For a much more detailed account of this whole controversy see "Technical Information for Congress: Report to the Subcommittee on Science Research and Development of the Committee on Science and Astronautics, U.S. House of Representatives, 91st Congress, 1st Session," prepared by the Science Policy Research Division Legislative Reference Service, Library of Congress, Serial A, April 25, 1969, available from the Superintendent of Documents for $2.25. This document considers thirteen cases of the problem of providing scientific information for Congress. If one were to use it as a reading, one could develop an entire course on topic 6 (Science and Government). It covers these

topics in considerable detail. The first topic covered is the "Astin Weeks Case." The other topics covered are the Point Four Program, the Inclusion of the Social Science and the National Science Foundation, Project Camelot, Mohole, the Test Ban Treaty, the Peace Corps, High Energy Physics, the Office of Coal Research, the Salk Vaccine, the Water Pollution Control Act of 1948, Thalidomide, the Insecticide, Fungicide, and Rodenticide Act of 1947, and Congressional Decisions on Water Projects. This is a 519 page document richly endowed with quotes and footnotes from the original sources.

Discussion questions for Lois P. Hudson, "Four-lane Menace to California's Redwoods," The Reporter 33 (Aug. 12, 1965), 34-38.

A controversy existed between lumbering interests and conservationists over whether a highway in California should be located through an exceptionally beautiful state park or on a somewhat more expensive route which would have avoided the park.

1. The most touching line in this whole article is the one in the last paragraph attributed to Governor Edmund Brown, "The Highway Commission is answerable only to God." Is this a fair description of the powers of the Highway Commission in your home state?

2. How should the Highway Commission be controlled? How should decisions be made about where highways are located and where funds are expended first?

3. Some states have used the system of letting the Governor personally direct the Highway Commission and allocate its budget for each year. Are there any drawbacks to that policy?

4. Have there been any controversies recently in Utah of a type similar to this one (i.e., cheapest possible highway construction vs. possible destruction of scenically beautiful areas)?

5. This article was written in 1965. How did this controversy eventually come out?

6. As a sideline for students interested in natural phenomena, on the second page, the author says, "...the summer fog that results from the meeting of the cold ocean air with the heated air from the dry inland valleys." Is that an accurate description of the causes of summer fog? Should one pick at authors like this for not getting their science correct?

My Answers for "Four Lane Menace..."

1. This is a fair description of the powers of the California State Highway Commission. The commissioners are appointed by the governor and serve for long periods of time, not subject to recall. Their funds are written into the Constitution and not appropriated by the legislature. The legislature has little control over what they do. Similarly, it is a fair description of the way things go in the state of Utah. In the winter of 1969-70 there was a confrontation between the governor and the State Highway Commission over who would remove snow from the parking lots in the local ski resorts. The governor ultimately conceded his inability to control the Commission and the Commission had their way.

2. I do not believe that anyone has a good solution to that problem.

3. This system leads to the most hideous forms of patronage. Under this system those counties which vote against the incumbent governor see their roads go to chuck-holes and see no highway construction at all. Similarly, highway construction becomes a permanent source of political pay-offs.

4. Yes. The State Highway Commission built a highway down the bottom of Echo Canyon thereby turning one of the most beautiful trout streams in the state into a concrete ditch. It was the cheapest solution.

5. Ultimately the highway people lost this one, probably because that area was included in the Redwood National Park. As of the summer of 1969, there was no sign that either of the two proposed routes were being built on, nor any indication that the route the Highway Commission proposes would be built on.

6. This is a completely inaccurate description. Cold, wet air meeting warm, dry air does not result in fog. Fog results when warm, wet air meets cold, dry air. In this case the warm Japanese current runs some distance off the coast of California. Much colder water occupies the space between the Japanese current and the shore. The winds blow warm, moist air from the Janpaese current over the cold water and thus produce the fogs which are so characteristic of the coast of Northern California. As to whether one should pick at authors for not getting their science correct, I answer no. Although Mrs. Hudson incorrectly understands the formation of fog, she seems to describe the social issues fairly accurately.

Discussion questions for, "Hot Engineering Triumph," The Engineer , November-December, 1967.

An account is given of the development of the self-heating shave cream.

1. This is described as "a research effort worthy of a Walter Reid, a Fermi, or a Salk,..." Is this a fair description of the results obtained here?

2. Is this product the most useful product which this group of people could have been assigned to design and develop? Were there no more pressing problems in our society for which they could work than that of developing a hot shave cream?

3. If your answer to the previous question is that there are more pressing problems which these people should have been directed towards, how would one go about directing them to those problems? What changes in our social organization would be necessary to so direct them?

My answers for "Hot Engineering Triumph."

1. Yes, this is a very significant technological accomplishment. In terms of the difficulty of the task assigned and the ingenuity of the solution it must be rated very highly.

2. No. Yes, there were more pressing problems.

3. This would require an enormous redirection of our national priorities and of the way in which we allocate wealth. In our system, technical manpower

allocation is done by financial reward. If we really want some problem solved, we announce financial rewards for those who solve it. In this case the management of the company believed there was enough financial reward for the potential solution of the problem to allocate the technical resources to do it. There is no indication that we believe that there is adequate financial reward now available for solving most of the other problems which everyone seems to be talking about, i.e., racism, pollution, poverty, nuclear war, etc. To get these people to work on those problems we have to find some way to allocate the financial rewards to make it seem attractive for them to do so.

IV-F-2. Additional material for Topic 6.

One additional reading which I have used in an Honors course is "How NSF Got Lost in the Mohole." This is sufficiently interesting that I will probably use it in future courses. The questions and answers follow.

Another topic worth considering here is the whole matter of technology assessment. The basic questions asked here are, "How can we decide in advance which technologies are beneficial, and which are not? How can we decide to allow or not allow the introduction of some technology?" A good reading on this subject is Harvey Brooks and Raymond Bowers, "The Assessment of Technology," Scientific American 222 (Feb. 1970), 13-21. The much longer congressional and NAS reports on the subject are cited as bibliography in this article.

Another reading which the teachers of this course will certainly enjoy and might wish to share with the students is David Irving, "German Atomic Bomb," Simon and Schuster, New York, 1967. The non-technical reader may be a little put off by the technical terms involved (criticality, neutron multiplication, diffusion lengths, capture cross sections, etc.). However, the technical reader will certainly find the account fascinating. A suitable reading to go with this would be Stephanie Broueff, "Manhattan Project," Little, Brown and Co., 1967. This recounts some of the successes and failures of the American atom bomb project. Comparing these two readings, one concludes that although we did a very poor job in many respects, we did a far better job than the Germans did.

Discussion questions for Herbert Solow, "How NSF Got Lost in Mohole," Fortune 67 (May 1963), 138.

This is a brief account of the difficulties the National Science Foundation had in selecting a prime contractor for the Mohole project and the political ramifications thereof.

1. Should the federal government fund large scale scientific undertakings like this? If not, who should?

2. Does the history as recounted here make you believe that a "pork barrel" aspect was involved in this?

3. Cite other examples if you know any of large scale scientific undertakings which have had this "pork barrel" flavor.

4. One of the widely stated objectives of the scientific community is to keep scientific undertakings out of politics. Was that successful here? Is it ever successful?

5. The writer of this article is obviously quite hostile to the selection procedure which was used. What kind of selection procedure should have been used?

My Answers for "How NSF Got Lost in Mohole."

1. The answer seems to be yes, because if we are to have this kind of large-scale scientific undertaking, there seems to be no other source of funding available. Certainly there is no direct profit to be obtained from these, and therefore, they are not likely to be financed by private industry for its own profit. The subsidiary question is whether large-scale scientific undertakings should exist at all, to which most scientists answer "yes."

2. Yes, it certainly does.

3. The Atomic Energy Commission in the mid 1960's conducted a search for sites for a giant particle accelerator. There was spirited competition by numerous states before the site was eventually chosen near Weston, Illinois. Much has been said about the location of the Manned Space Flight Center in Houston, indicating that this site was chosen for political reasons rather than technical ones.

4. Apparently not. Clearly political motives got involved here. Much other science has been kept out of politics successfully, so it is not an absolutely impossible goal, merely a difficult one.

5. It seems clear that the criteria which would be used to judge the proposals should have been published in advance before any proposals were accepted. If this is done, then there can be no later claims that the criteria were adjusted to suit one particular bidder. In this case it seems clear that the oil companies and others who went to major efforts preparing their proposals were treated rather shabbily, since ultimately it was decided that they should not have been allowed to even propose.

   For more details see "Technical Information for Congress, etc." which is cited in the discussion answers for the Astin-Weeks case.

IV-F-3. Examination questions for Topic 6

1. C. P. Snow, p. 30 of "The Two Cultures, " says "industrialization is the only hope of the poor." Is that true? If your answer is yes, give convincing arguments that there can never be a happy and prosperous non-industrial society. If it is not true, give a current example of a happy and prosperous non-industrial society or the formula for producing one.

2. One of the currently debated proposals in this country is that we institute a policy of "technology assessment," by which some board or agency like the Food and Drug Administration would be set up to review all new technologies and rule on whether or not they should be allowed to be introduced to the public.

What are the advantages and disadvantages of that proposal?

3. See question 2 which describes the policy of "technological assessment." Suppose we had such a policy and a board to make assessments in 1900, and they were asked to decide whether or not to allow the introduction of automobiles. What would they most likely have decided? How would they have reached their decision? What principal points would they have considered?

4. By national referendum we have just decided that we do not want to build the SST. This immediately puts about 50,000 people out of work. These people are highly skilled at designing and building mechanical, electric, electronic, hydraulic, etc. devices. They have no particular skills at social science work, teaching, peace-corps-type jobs, etc. We can put them all on relief, or we can set them to work on some project chosen by the government to be of great social value. What device, system, gadget, etc. should we ask them to create? Why that one?

5. In the past few years there has been a bitterly contested strike of the grape pickers in California. (You all must have seen the "Boycott California Grapes" signs). Assume for the moment that you are president of the University of California. One of the most famous parts of your institution is the campus at Davis (near Sacramento) which has made great strides in mechanizing farm production. Most likely they were working on the mechanization of grape picking at the time the strike began. What action should you take toward that mechanization effort; speed it up, slow it down, do not interfere either way? Present the reasons for your decision. List all the significant issues.

6. In "The Two Cultures," Snow is very concerned about the communication gap between the literary intellectuals and the science intellectuals. Explain why he thinks this gap is a dangerous one, and what he thinks are the consequences if this gap is not closed. Then explain why you think this gap is as serious, more serious, or less serious than Snow contends it is.

IV-F-4. Paper subjects for Topic 6

1. The San Francisco Chronicle has conducted a long campaign to tear down the Embarcadero Freeway, on the grounds that it is ugly. I would like to see a good history of that, along with a reasoned discussion of how such conflicts between efficiency (i.e. lowest cost) and esthetics should be solved. How should we decide how much money we are willing to spend for beauty or for not messing up our view of the bay?

2. Introduce "legislation" to the U.S. Congress to control technology. Discuss the problems in composing this legislation, of gaining Congressional acceptance and of putting the legislation into operation.

3. Education technology is still an infant. Lay out a program which will develop this technology at an "optimal" pace. Define your criterion of optimal. Alternatively argue that the development of technology should not be guided by the U.S. Government.

4. Most scientific research in the U.S.A. is funded by the Federal budget. How are the available funds divided? How should they be divided?

IV-G. Topic 7. How Safe Is Safe Enough?

This topic has only been used on an Honors section of the course; it seemed quite successful with them. I plan to use it in a regular undergraduate section in the near future.

The basic question here is, "How much should we be willing to pay for safety?" It is clear that a large number of accidental deaths in this country and in the world could be prevented if we were prepared to spend enough money to prevent them. How much should we be willing to pay? There are related questions of safety vs. money concerning environmental matters, i.e. the dumping of nuclear wastes. These are taken up in this topic. The main reading is Ralph Nader's, "Unsafe at Any Speed", followed by a series of journal articles.

IV-G-1. Discussion questions and answers for Topic 7.

Discussion questions for Ralph Nader, "Unsafe at Any Speed," Pocket Books, New York, 1966.

Ralph Nader attacks the automobile industry for what he considers their very poor performance in designing safety into their automobiles.

1. Is this book basically scholarly, entertainment, sensationalistic, or _____?

2. In his discussions of "human engineering," he implicitly raises the question of whether we should fit the machines to the men or the men to the machines. Which approach is safer? Which is more expensive?

3. On pages 70-71, he presents his view of the existing safety patents, as opposed to that of Arjay Miller. Who is right?

4. On page 87 he sets forth the industry's position on forcing safety on the public. Under what circumstances should the alphas (you and I) force unwanted safety measures on the betas, gammas, etc. (all those other people, who don't really understand what is involved and can't take the time to master the crash statistics)? Under what circumstances should we do as the auto companies suggest and let the market decide?

5. On page 89 he cites the industry's tendency to meet outside criticism by simply stating that "we know the situation better than you." Is that ever a valid response? Is it a common response?

6. From the discussion of pages 103-110, would you conclude that the Cornell Crash Research Group have "sold their souls" to the auto companies? What defense could they make for their actions?

7. Should the auto engineers quit their jobs when their safety recommendations are ignored? Or should they continue to work from within the companies to get them implemented? Or what other options should they follow?

8. On page 153 he cites the ethical standards of the NSPE. Why haven't these

been applied to the auto problem?

9. On page 155 et seq., he calls for more detailed "automotive engineering" courses in universities. What are the advantages and disadvantages of such a proposal?

10. On page 157 he says "missions need only be defined and financed in order to be performed." True? If not, what are the examples to the contrary?

11. The whole section on the safety establishment raises the question of whether exhortation is a satisfactory way of solving serious problems. Is it a practical way to solve safety problems?

12. His book is a rather serious criticism of the organization of the American auto industry, and of our financial and political institutions. There are numerous autos produced by countries with much different organizations. (Renault is owned by the Government of France, Volkswagen was owned by the German Government, the Eastern European countries make cars in state-owned enterprises.) Have these cars been better from a safety standpoint than those made in the U.S.A.?

13. Did this book have any political influence?

My answers for "Unsafe at Any Speed"

1. This is basically sensationalistic pleading.

2. Most people believe that fitting the machines to the men is safer. It has not really been shown that one is more expensive than the other.

3. I think Miller is right. There are lots of patents which do not represent real inventions or really practical ideas.

4. This is the basic dilemma in this whole field. To what extent should those who know force their will upon those who do not? In some fields we have answered "to a very great extent," for example in the field of airplane design. On the other hand, in the field of autos we have, until quite recently, answered "to a very small extent."

5. It is sometimes a valid response if there are no technically trained people on the other side. It is a very common response, generally made now by those who are being attacked for pollution activities.

6. One would like to look into the details of that situation. Nader certainly paints them as being a bunch of intellectual prostitutes.

7. It would appear that most of them continue to work from within. The other option to consider would be forming a really effective professional engineering organization which they have not done.

8. The ethical standards cited really only apply to consulting engineers. When corporate engineers are involved it has always seemed impractical to try to do this.

9. One of the advantages would be having an outside critical group really

active in the field. The disadvantage would be the disadvantage of training people for a specific industry as opposed to training them to be more broadly oriented engineers. We have gone a long way in the latter direction; most of us think we have gone the right way.

10. Not true. Examples: the cancer effort, the urban housing effort, Vietnam.

11. Apparently not.

12. I have seen no evidence to support that view.

13. This book had considerable political influence, particularly after GM made the colossal public relations error of hiring a private detective firm to try to "get some dirt" on Nader. This not only failed but backfired explosively.

Discussion questions for Ralph Eshelman, "The Auto Safety Furor: Its Meaning to Engineering," Engineer, July-August, 1967, pp. 8, 9, 19.

A professional engineer points out the difficulties of engineers in the auto industry in trying to build safety into their products.

1. On the right side of the first page he says, "Unlike the doctor, lawyer, ..." This implies that these professions have societies largely directed toward protecting the public from the misuse of their profession. True? Is this the basic function of the AMA, American Bar Association, etc.?

2. On the lower left corner of the second page he cites American Motors' poor customer response to safety items. Many scholars have commented on the non-rational approach to selling autos (i.e., the auto as a toy or wish-fulfillment symbol, rather than as a utilitarian device). Is this the reason this failed to sell? Is the reason we have extensive public safety activities in commercial aviation that we see that as a utility, rather than a form of wish-fulfillment? Or what other reasons can be adduced for this difference?

3. Does his scheduling argument suggest that the annual model change is inimical to safety?

4. Why have the engineering professional societies failed to act in this matter?

My answers to "The Auto Safety Furor"

1. No, I think not. I think the basic functions of these organizations have not been to protect the public but to look out for the financial interests of the groups they represent. They also have had some public safety functions, but these again have been largely the case of protecting the image of the group rather than any direct public safety situation. Generally, they have tended to hush up critics rather than providing them a platform.

2. This seems like a reasonable argument, although I am not certain it is correct. I think it is correct that we do see aviation as a utility

rather than wish-fulfillment, at least commercial aviation.

3. Yes, I do think it does.

4. Because they have faced a more powerful competitor in such a matter, their competitor in this situation would be the industries who employ the engineers. These industries are generally a great deal more powerful than the engineers.

Discussion questions for David A. Anderton, "R.A.E. Engineers Solve Comet Mystery," Aviation Week 62, February 7, 1955, and February 14, 1955.

This is a historical account of the Comet airplane, the first commercial jet aircraft. Two of these exploded in flight due to a design failure, killing all of their passengers and crew.

1. Is the general tone of this article favorable to the british aviation industry? Should it be favorable to the british aviation industry?

2. Should these airplanes have been tested to destruction this way before they were put into passenger service? If so, why were they not?

3. Why did this problem first appear with this aircraft? What sorts of general conclusions can one draw from aircraft safety from this case?

4. Based on this case, what general policies would one institute for the testing of radically new kinds of aircraft?

My answers for "R.A.E. Engineers Solve Comet Mystery"

1. The general tone is quite favorable to the british aviation industry. This is really questionable since they did put into service a plane which was unsafe. However, since this is an article in an engineering journal which is largely dependent on industry advertising, they take a favorable viewpoint.

2. Probably they should have. However, this would have been quite costly. They didn't foresee this kind of problem so they didn't run the test.

3. This was the first commercial jet aircraft and presumeably the first aircraft to fly this high, pressurized. Therefore, the pressure loadings on the inside of the cabin were more severe than in any other aircraft to date, and that's probably why they got into this trouble.

4. One can only conclude that when a radical departure is made in aircraft design, all conceivable and several inconceivable failure modes should be tested.

Other source material on the Comet is: Tom Bishop, "Fatigue and the Comet Disasters," Metal Progress 67, May, 1955, p. 79. This is better for a technical audience, but probably not for a non-technical one.

Discussion questions for W. L. Templeton, "Disposal of Liquid Wastes into Coastal Waters," Chemical Engineering Progress 66, February, 1970, pp.45-50.

This is an account of Britain's policies and procedures for evaluating the safety of discharging radioactive wastes into coastal waters. The level is slightly technical for a general audience, but I consider the article understandable to bright undergraduates outside of science.

1. Is, as he says, the "zero point" unrealistic?

2. Are the risks of discharging radioactive wastes, as he says, understood?

3. How safe are the IRPG standards? How were these arrived at? How should they have been arrived at?

4. What is the definition of a rad? How did we decide that 1 rad/30 years was acceptable?

5. Are the oceans really a common dumping ground? Who speaks for the other users of the oceans in the question of dumping radioactive wastes in them? Who decides how much each country can dump?

6. How can one be sure he has correctly chosen the critical population?

7. How can one be sure that the direct radiation exposure to man is the most dangerous part of this?

My answers for "Disposal of Liquid Wastes"

1. That is a highly debatable point. One wonders if it is totally unrealistic to say that such wastes shall not be discharged at all.

2. The history of the continual reduction of allowable standards would make you wonder whether this is true or not. I am inclined to assume that they are fairly well, but not totally, understood.

3. I don't really know. These were probably arrived at by comparing the dosage with that due to natural sources e.g. cosmic rays and radiocarbon in the atmosphere, and radioactivity from granite rocks, etc. That is probably as reasonable a way of deciding as any, although the acceptable ratio is clearly an arguable point.

4. It appears that the definitions are as follow: A roengten is defined as that amount of radiation which will cause an interaction of 83 ergs per gram in air. This also turns out to be the amount of one statcoulomb per cubic centimeter in air. A rad is the amount of radiation which would produce one hundred ergs per gram under the same circumstances where a roengten produces 83, so that a rad is 1.2 roengtens. We also use to have around a rep which stands for roengten equivalent physical, which turns out to be 93 ergs per gram of tissue and a rem, which is equal to one rad times a quantity called the relative biological effectiveness which is different for different energies and different particles. For example, for neutrons the relative biological effectiveness is 10. A Curie, on the other hand, is a rate. It is equal to the amount of radiation emitted by one gram of radium and is roughly equivalent to six rads per hour at a radius of 1

foot. The decision that one rad per thirty years was acceptable is presumeably based upon measurements of background radiation.

5. We seem to believe that the oceans are a common dumping ground. The U.S. Army planned to dump nerve gas in the ocean in 1969. This raises the whole question of the commons. No one has worked out any sort of rules as to who the other users are, what their rights are and what the dumping rights are.

6. One can only hope that he has done it, and that he has done his homework well. I don't believe one can be sure.

7. I don't know the answer to that question either.

For more details on this problem see "A Source Book in Support of Electric Power and The Environment" available from T. J. Slosek, Mail Code 828, General Electric, 175 Curtner Avenue, San Jose, California. This presents a strong case for the view that current safety standards are adequate.

Discussion questions for Chauncey Starr, "Social Benefit vs. Technological Risk," Science 165, September 19, 1969, pp. 1232-38.

This is an effort to decide what criteria ought to be used in allocating cost to improve safety or reduce accidents.

1. How reasonable is his assumption that the historical accident data reveal the historically revealed social preferences?

2. At the top left of page 1233 he indicates that it will take decades to put into use the pollution control technologies now known. Why? Must it?

3. Is it reasonable to ask the question, "How safe is safe enough?" Is this question better left unasked?

4. In his example of the commuter in the lower right of page 1233 is the accident hazard in driving likely to play any major role in the decisions? Or are there other considerations which are more important? Such as?

5. Is the general public impression that the dangerous mining jobs are the high-paid ones, or is it the contrary? Is there another significant factor in this set of data?

6. He also suggests that the acceptable risk is proportional to $(\text{wages})^3$. How far up the wage scale is this likely to go? Does one reach a level at which more money will not induce one to undertake further risk?

7. He proposes that in the nuclear power industry the safety requirements for protection of the plant are much more stringent than those for safety of people in the surrounding community. True? If so, are there other industries where this is likely to be the case?

My answers for "Social Benefit vs. Technological Risk"

1. This seems to me to be a completely wild assumtion because we have very little evidence around to suggest that social action to control technological

risk has ever been taken.

2. It will take that long to put them into action if we continue with our present political beliefs that everyone is entitled to pollute the commons. It does not have to. If we ever decide we want to have those things in, we could have it done in five years.

3. I think it is reasonable to ask the question.

4. I think the risk of accident is very seldom taken into account in such decisions. The other decisions which are important are the person's belief in the quality of life is superior where he lives in the suburbs compared to the quality of life living in central city areas.

5. The general impression is to the contrary. The other factor in this set of data is the effect of the unions. The coal mining unions have been more effective in forcing settlements by using the public as a hostage than the unions involved in metal mining or stone mining because they cannot use the public as a hostage.

6. I assume that one reaches a level at which more money would not induce one to take further risk. It is hard to imagine a man who is making $50,000 a year going to an extremely risky situation for $100,000 a year.

7. Probably. Also the same arguments certainly apply to most chemical processing plants and power plants in general.

IV-G-2. Additional materials for Topic 7.

An alternative to "Unsafe at Any Speed" would be J. O'Connell and A. Meyer's "Safety Last, an Indictment of the Auto Industry," Random House, 1966. This book is very similar to "Unsafe at Any Speed" except that it is shorter and less detailed. The basic spirit is the same and many of the cases cited overlap. I consider them equal in quality, but "Unsafe at Any Speed" is readily available in pocketbook which this one apparently is not.

None of the material covered in this section deals with what would be called "civil engineering" failures (i.e. bridges, dams, buildings, etc.). There are several things one could use here. The most interesting perhaps is D. B. Steinman, "Suspension Bridges: The Aerodynamic Problem and Its Solution," The American Scientist, 42, 1954, pp. 397-438 and p. 460. This is a fascinating account of Steinman's work on the aerodynamics of suspension bridges. This problem became particularly interesting when the Tacoma Narrows Bridge fell in 1940. Steinman modestly admits that he told the designers of that bridge that it would fall down and how they could fix it; they ignored him and the bridge fell. An interesting sidelight on Steinman's article is Steinman's amazing ego. He clearly made many great contributions in this field, but he recognizes no one else as ever having contributed anything. One may sense this from the list of bibliographic references at the end of its article; there are nineteen, of which eighteen are by Steinman himself and the nineteenth, by F. J. Maher, is entitled "Tests Confirm Steinman's Theory of Bridge Oscillations."

Another choice is Charles F. Outland, "Man-made Disaster, The Story of St.

Francis Dam," Arthur H. Clark Co., Glendale, California, 1963. This is a short, entertaining account of the failure of the St. Francis Dam and the numerous consequences thereof. The engineering inadequacies which resulted in the failure are clearly described. A similar disaster occurred in February, 1964, in Italy when a large landslide occurred into the reservoir beyond the Vaiont Dam. See George A. Kiersch, "Vaiont Reservoir Disaster," Civil Engineering, 34, March 1964; "Lesson Learned From Dam Disasters," Engineering, May 15, 1964, pp. 681-683, and G. Gaskill, "The Night The Mountain Fell," Readers Digest, May, 1965, pp. 59-67. Finally, along the lines of civil engineering safety is Thomas H. McKair, "Building Failures," McGraw Hill, 1962. This is not a book for the layman, and is limited to investigating the various kinds of structural failures which have occurred in buildings in the United States. It makes interesting reading for engineers and indicates the general causes for this kind of failure.

IV-G-3. No examinations have been given on Topic 7.

IV-G-4. Paper subjects for Topic 7.

1. In some cases of engineering failures it is easy to see who is to blame and who should pay for the damages. [Outland, D. F. "Man-made Disaster, the Story of St. Francis Dam," A. H. Clarke Co., Glendale, California, 1963.] In others it is much harder. An interesting case to study would be the Italian dam disaster of a few years ago in which there were many lives lost. Who was to blame for that? How could it have been avoided?

2. A recent article [Barry Commoner, "Attitudes toward the Environment; A Nearly Fatal Illusion." Presented at an AAAS Symposium in December, 1968. (As far as I know this has not appeared in a journal yet.)] indicates that radioactive iodine 131 from nuclear power plants is a current, serious health hazard. The AEC disagrees. Who is right?

3. As far as I know, the first real industrial safety regulations came about in the period from 1850 to 1900. Did these come about largely as a result of worker pressure for safer working conditions, or did they come about as as result of outsider pressure, i.e. from social reformers?

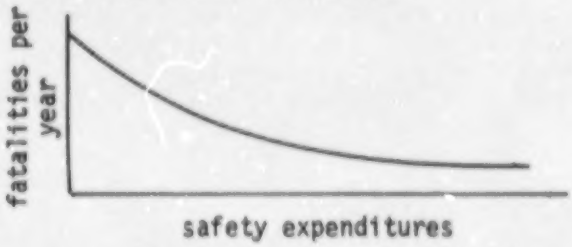
4. One of the fundamental questions in compulsory safety regulations is to what extent we ought to let the market place decide and to what extent we ought to force people to take safety measures which they might not take voluntarily. In this class we have discussed fairly extensively the case of automobiles, and slightly some other cases. Pick some general area of safety regulation which we have not considered in class and explore this question historically.

5. If I have the history correctly, then the permissible radiation doses for various kinds of people in the United States have consistently decreased over time. Is this the correct history? If so, why did it occur this way?

6. In the aborted Apollo 13 moon mission the entire emotional resources of the country and enormous physical resources were devoted to saving the lives of three men who were in difficulties in outer space. During the time this was going on approximately 500 people were killed on America's highways in auto

accidents and probably 150 were killed in the Vietnam war. This would lead you to believe that we have entirely different value systems for the hazards in various kinds of activities. It seems clear that we will spend a great deal more time and effort to avoid one fatality in outer space than we will on our highways or in Vietnam. Prepare a comprehensive paper indicating how this value system works out and which are the areas where we will make the greatest effort to prevent fatalities, and which areas are the ones in which we will make the least effort to prevent fatalities.

7. I believe that accidents vs. safety cost curve is like this for almost all safety problems. I would like to see a well documented example showing for some specific problem whether or not this is the correct type of curve.



8. In class we discussed the case of the comet airplane, which is one of the famous air crash investigation cases in history. A similar case is that of the Lockheed Electra. I have been unable to find a good history of that; however, I have not looked very extensively. I would like very much to see a paper which gives a good history of that case.

9. In recent years we have had a very effective air safety establishment which looks at the problems of aircraft crashes very vigorously. What is the history of this? How did this come about? Why is the history of this so different than the history of automobile accident safety?

10. In recent years we have had a vigorous controversy in this country about the placing of nuclear power plants in urban areas. One of the major considerations in the opposition to such power plants has been that of safety. For example, the Pacific Gas and Electric Company began construction of a nuclear power plant at Bodega Head only to eventually abandon the project because of public opposition based to some extent on safety considerations. Prepare a history of this and related safety contests about nuclear power plants, and indicate to what extent this is irrational hysteria and to what extent it is solid and logical safety thinking.

11. The State of New York sponsored an extensive program to develop a "safety car." [____ "The Safety Sedan," New York State Department of Motor Vehicles, Albany, New York, 1969.] Did this work have any effect on the design of mass produced American cars? If not, why not?

IV-H. Topic 8. Systems, Modeling, Optimization, etc.

This topic has only been tried on an Honors class. It requires some further work before I will consider it really suitable for use in an undergraduate class.

Currently one of the "in" words in the engineering profession is "systems engineering." This along with "modeling" and "optimization" are said by some to be the engineering tools which will solve the social and environmental problems of our time. The question which immediately arises is whether this is indeed the case or merely a self-serving publicity effort by those who wish federal funds to practice their trade in these areas. The purpose of this topic is to introduce the student to what these words mean or should mean, and give the student some clue as to whether any of the claims which are now being made for the universal efficacy of these approaches are valid.

I do not have a long reading for this section which I consider satisfactory. I used chapters 2, 3, and 4 of part one of "The Man-made World," McGraw Hill, 1969. The questions I assigned were questions from the ends of the chapters. I am not completely satisfied with this because we did not have enough time to work through all the problems which I think one must do if he is to make maximum use of this material. The other readings which are discussed below were, however, quite satisfactory.

IV-H-1. Discussion questions and answers for Topic 8

Discussion questions for G. Nevill and D. Falconer, "Critical Path Diagramming," International Science and Technology, October, 1962, p. 43.

Critical path diagramming is widely used in planning large construction and military projects. A simple example is given here.

1. One frequently cited advantage of the "scientific management methods" like CPM is that they "force you to think in a disciplined way..." (See page 44). Is this true?

2. Is this type of analysis likely to be of more value in complex problems than simple ones, or the contrary?

3. Prepare a CPM diagram for obtaining a degree from the University of Utah, in your major. Is there one "critical path"?

4. One of the current "in" ideas in Washington is the application of defense technology to social problems. Suggest a social problem for which CPM would be useful.

My answers for "Critical Path Diagramming"

1. Yes, this is a distinct advantage. However, there is another distinct advantage in that numerous things have resulted which one simply could not get at intuitively. Many of the systems dealt with are so complex that no one can possibly do by intuition or disciplined thought what can be accomplished by numerical analysis.

2. In complex problems. For simple ones this is a rather straightforward thing which doesn't really require a great deal of thought. On the other hand, for complicated ones this method can really make a contribution.

3. Two such diagrams were prepared by people in the College of Engineering. Generally there is, but I have not followed these through to see that it's the case. It depends on how many courses are only offered once per year as opposed to being offered frequently, and on how many courses have prerequisites.

4. People have considered, for example, the problem of establishing a "nuplex." There is a CPM study of those which indicate that the first thing one would do would be to plant shade trees. The grounds for doing so are that the technical people who would have to run such a nuplex would have to have a decent place to live or they wouldn't stay. The shade trees take the longest for that. Similarly, any serious discussion of rebuilding cities will involve this sort of process. If we had had any sort of serious program for ending racism, we should have made such a diagram, but we haven't.

Discussion questions for J. B. S. Haldane, "On Being the Right Size," in "Possible Worlds," Harper and Brothers, New York, 1928.

Haldane shows the limitations of model studies and also shows what physical reasoning can tell us about comparative anatomy.

1. Haldane suggests that biological systems cannot be successfully tested with scale models of different sizes. What kinds of systems can be tested with small-scale models?

2. What advantages are there in being able to test a small-scale model of a system rather than the system itself?

3. How did he obtain the statement on page 955, that for aircraft of fixed shape, speed must be proportional to the square root of length?

4. On page 955 he says "comparative anatomy is largely the story of the struggle to increase surface in proportion to volume." Why? Exceptions?

My answers to discussion questions "On Being the Right Size"

1. Airplanes, ships, chemical reactors, pumps. Basically the model scheme has been most successful in the areas of fluid mechanics, chemical reaction design, structures, etc.

2. An enormous saving in cost and time and human lives.

3. The mass or weight is proportional to an appropriate length dimension cubed. The lift is proportional to the wing area times the velocity squared. However, the wing area is proportional to the length squared. If we equate lift and weight, we find that the velocity squared is proportional to the length or the velocity proportional to the square root of the length.

4. The reasons for the increased surface to volume are the necessity of increasing diffusional surface area per volume so that the diffusional

processes on which life is based can go on. An exception to this which he doesn't really treat is the problem of heat conservation. In truly cold climates most of the animals are big and are as close to spherical as seems practical. Witness for example the polar bear, the seal and other animals which have taken up this kind of shape. An interesting thought on this whole matter is the hypothesis advanced in a recent Scientific American that the reason for the antlers on large animals is heat rejection. These antlers during the hot part of the summer are covered with skin containing blood veins, therefore they allow the animal to reject large quantities of heat. From the article it was not apparent that this was something that was certainly true but merely an interesting hypothesis.

Discussion questions for H. O. Fuchs, "The Wright Brothers' Airplane," UCLA Engineering Development Program Report #2-64. (Available through Stanford University Case Study Program).

This is a historical account of the technical problems the Wright Brothers encountered in building their airplane and the intense and thorough preparations they made before their first flight.

1. Common folk belief in the USA holds that the Wright Brothers were unlettered bicycle mechanics. Does this history support that view?

2. How important were mathematical and theoretical models in their development of the airplane?

3. How did they decide between theory, model test and full scall test?

My answers for "The Wright Brothers' Airplane"

1. This history certainly does not support that view. It would lead one to believe that the folk mythology persists in the face of the facts when the folk mythology is so attractive. Here the folk mythology supports the view of the common man that all those people who read books aren't really better than a smart, but unlettered, guy from the lower classes. Unfortunately the history here contradicts that.

2. They were extremely important. These people were entirely on top of the literature and entirely on top of the mathematical treatment of the data which was available at that time. Without their extensive calculations they would probably never have made it.

3. They showed true engineering genius here; namely they looked at each question in terms of how could they gain the necessary knowledge with the minimum expenditure of time and effort. When theory and model test would do it, they did that. When those failed they were obliged to go to full scale test.

Discussion questions for R. Nicholas Hazelwood, "Operations Research," International Science and Technology, January, 1966, pp. 36-49.

Operations Research is the name for a group of related managerial techniques and applications of mathematics and science to business and management problems. It is described here with several examples.

1. On page 37 he says, "this mathematical model is a key element in operations research." Does this mean that OR is inapplicable to those things for which mathematical models cannot be found?

2. How does one learn to make the simplifications he describes in the first paragraph on page 37?

3. On page 41 he suggests that good observational data are more important than sophisticated mathematics. True? Always?

4. What social or political problems do you suggest applying OR to?

My answers to discussion questions for "Operations Research"

1. As originally construed, operations research did involve some very non-mathematical and non-modelable things. For example, there was the famous case in which the users of ground-base anti-aircraft fire wanted an anti-aircraft gun which would point straight up. The operations research people completely answered this question by asking a group of anti-aircraft gunners to point straight up. They all pointed at an angle of about 70 degrees to the horizontal. Similarly, there is the famous story of the surviveability of aircraft in bombing raids over Germany. There was a long study of what kinds of accidents were seen on the planes coming home and how to counter them, until one bright operations researcher said, "Let us look for the kinds of things we never see on planes coming home," and thus found what the real weak points were. However, it is clear that operations research has been much more successful in areas where mathematical models can be found than in areas where none have been found.

2. This is done by experience and judgment and is what separates the men from the boys.

3. Generally this is the case. There is the famous case of Newton who presumeably would never have come upon his laws of universal gravitation if he did not have access to Kepler's reworking of Tycho Brahe's data on the motion of the planets. Sometimes, however, one can write down a model and make some significant predictions from it without any data. The stories about the efforts to develop rational anti-submarine warfare programs suggests that this was done by the British largely on the basis of intuition, and with considerable success.

4. It has been suggested by Moynihan that this sort of approach to our whole welfare problem would be rewarding. Similarly, such a thing could be done to housing or transportation, neither of which has been given much intelligent study.

Discussion question for Hendrick W. Bode, "The Systems Approach," in "Applied Science and Technological Progress," a Report to the Committee on Science and Astronautics of the U.S. House of Representatives by the National Academy of Sciences, June, 1967, Superintendent of Documents, $1.50.

The systems approach is a way of viewing complicated problems. One of its most famous exponents here gives examples and some background on how this approach has proven profitable.

1. Does a renaming like that mentioned at the top of page 74 generally reflect what the agency really does, or does it reflect the area of responsibility it wishes sovereignty over?

2. The critics of SE often raise the thought he gives at the bottom of page 75, that SE is just a fancy name for common sense and careful work. True? Do his following examples support or refute this idea?

3. On page 78 he indicates that SE involves not only design and production, but also training of users, maintenance, etc. If that is the real definition, then which kinds of industries now use SE, and which do not?

4. Some SE's have said that they spend their lives "fighting suboptimization." What would this mean? Give examples from everyday life of suboptimization which is harmful to overall good.

5. On the top of page 83 he suggests that SE often forces the user to decide what his real values and needs are. Would the use of SE on social problems have the same effect?

6. On page 91 he emphasizes the necessity of having the "...adequate and broad base of new science and technology before proceeding." Is this really necessary? If so, do we have this base to apply SE to racism, poverty, pollution, etc.?

My answers to discussion questions for "The Systems Approach"

1. Historically this sort of thing has not been a reflection of facts but an effort to claim territory.

2. Yes and no. Clearly much of systems engineering simply means a thorough and careful evaluation of all knowable aspects of the situation. This is certainly just common sense and careful work. However, in some cases, they have developed methods and techniques which are more than just common sense and careful work.

3. Clearly industries like the telephone industry follow the entire sequence from manufacture to operation to maintenance entirely in one house and can, indeed, do it as a systems operation. Likewise, the airlines do fairly well at this because they set the specifications for the products to the manufacturers and control most of the remainder of the system, including the handling of the users, etc., although this is somewhat broken up because of the multiple number of airports they have to deal with and their problems with the FAA, etc. The auto companies are the exact opposite of this; the manufacturer ceases to have responsibility for the product, its maintenance, its use, the instruction of the drivers when it is delivered to the consumer. The other parties involved are the people who build the roads, who bear no relation to the drivers, the people who manage the insurance and the legal struggles, who bear no relation to anybody at all. Each one of them suboptimizes.

4. By suboptimization, we mean each part of an overall system working to maximize its advantages at the expense of the entire system. Clearly, it is advantageous for each community to save the cost of a sewage treatment plant,

and throw its sewage in the nearest body of water. This optimizes its situation but does not optimize the situation for the people downstream of them. Another example is the whole auto industry: the groups involved are the auto manufacturers, the oil companies, those who build roads, the insurance companies, the police, and the court system, the auto suppliers, etc. Each one of these tries to run its own part of the operation in the most efficient way, without considering changes that could be made in other parts of the operation which would help it or the negative effects of what it does on the other part of the operation. Consider, for example, the case of lead in gasoline. The auto companies have now decided that they want the lead out of the gasoline because it will help them. However, it will certainly hurt the gasoline manufacturers. And it is not clear that the public will benefit overall. However, the auto manufacturers are in a position to force this down the gasoline manufacturers' throats, or so it seems, and presumably will.

5. Yes, I think it would, and I think that would be the most beneficial aspect of the whole thing.

6. I hope it is not true. He certainly says this strongly, but it is my opinion that we do not have this broad base of science and technology for such problems as racism, poverty, pollution, etc., and therefore are going to have to go with the limited knowledge we have. If he's right that we cannot make any useful progress without the basis of broad scientific understanding, then we are in worse trouble than I think we are.

IV-H-2. Additional material for Topic 8.

This topic is the basic topic of Volume I of the "Man-made World" series sponsored by the National Science Foundation and the National Academy of Engineering. As mentioned, I used some of this; I question whether it is really suitable for the use I intend here.

For a somewhat more mathematically-inclined audience I suggest Lewis Iscoll, "How To Solve Optimization Problems," Chemical Engineering, 69, February 19, 1962, pp. 107-116. This is an extremely clear and straightforward presentation of the problem; he chooses as his illustrative example the homey topic of the proper brewing procedure for coffee.

There has been a certain amount written on the application of sy[illegible] engineering to social problems. For example, Harold D. Watkins, "Syst[illegible] Engineering Aids Social Problems," Aviation Week and Space Technology, January 31, 1966. The striking thing about these articles is how little they have to offer in the way of genuine applications where this sort of te[illegible]gy transfer has been successful.

IV-H-3. No examinations have been given on Topic 8.

IV-H-4. Paper subjects for Topic 8.

1. There has been considerable talk in the popular press about using the

"systems engineering" talent of the aerospace and defense industries to solve social problems. [Space Aeronautics, 49, 30-1, March, 1968, and Aerospace, 5, 2-5, February 1967.] Has anything good come of this yet? Is anything good likely to come of it? How soon will we know?

2. You have been commissioned to plan and build a new major city of 500,000 people in an area of farmland in the mid-western U.S.A. Prepare a CPM diagram for this task.

3. Should city planners use the systems approach? Or would this be sub-optimizing; i.e. should the approach be used at a regional or national level?

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As a convenience to potential users, we have prepared a set of all of the readings mentioned in this report. Copies of this set may be obtained by sending a check for $5.00 to Dean's Office, College of Engineering, University of Utah, Salt Lake City, Utah 84112.

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VI. STUDENT RESPONSE

As mentioned previously, this course has been taught three times as a regular University class and twice as an Honors course. The University of Utah has a student-run course evaluation program which gives feedback to the professors as to the students' view of the courses. The student evaluation is regularly published so that other students may know what the previous students have thought of the courses which are offered.

Although the intended audience for this course is a non-technical group of students, approximately one-third of the students taking the course are scientists and engineers. They are not discouraged from taking the course and it does count for them as part of their general education requirement.

In general, the student responses seem to be as follows. First, they enjoy the course and recommend it fairly highly to their fellow students. Second, they think that it is too much work and too much reading. Third, the lower classmen among them are disturbed that there are not simple and concrete answers to the questions asked. They prefer the "swallow and regurgitate" form of class in which the professor tells them and then asks them whether they remember what he told them. Some students complain bitterly that this method is not used in this class. On the other hand, there are numerous comments that the "non-regurgitation" is one of the most attractive features of the class.

The general education program conducts its own evaluation of general education classes and uses this evaluation to weed out the least successful ones. In terms of over-all rating, this class has consistently ranked higher than average among general education classes and has been continued in the program for academic year 1970-71.